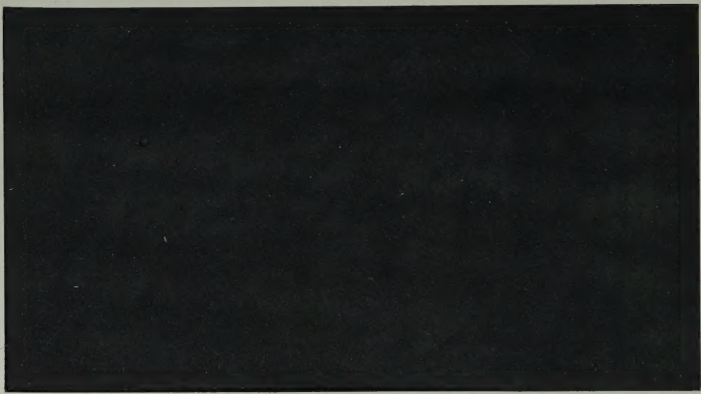
MODEL 330B/C/D

DISTORTION ANALYZER

Serials Prefixed 351-
With Backdating to serial 672

HP Part No. 330B-910

HEWLETT hp PACKARD



OPERATING AND SERVICE MANUAL

MODEL 330B/C/D
DISTORTION ANALYZER

Serials Prefixed 351-
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HP Part No. 330B-910

00041-4

Printed: OCT 1964

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Table 1-1. Specifications

MODEL 330B

Distortion Measurement Range:
Any fundamental frequency, 20 cps to 20 kc.

Frequency Calibration Accuracy:
±2% entire range

Elimination Characteristics:
Fundamental frequency reduced by more than 99.99% (80 db). Second harmonic attenuation less than 17% (1.5 db) for fundamental frequencies 20 cps to 5 kc; less than 32% (3 db) for fundamental frequencies 5 kc to 20 kc.

Accuracy:
Residual frequencies are measured to within ±3% of full scale value for distortion levels as low as 0.5%. Meter indication proportional to average value of residual components. Distortion introduced by instrument less than 0.1%.

Sensitivity:
Distortion levels of 0.3% are measured full scale. Levels of 0.1% readable with good accuracy.

Distortion Meter Input Impedance:
Approximately 200,000 ohms, 40 pf shunt

Input Level for Distortion Measurements:
At least 1 volt rms

Voltmeter Sensitivity:
Full scale sensitivities of 0.03, 0.10, 0.30, 1.00, 3.00, 10.0, 30.0, 100 and 300 volts. Nine ranges spaced exactly 10 db. DB scale: -12 db to +2 db, calibrated on zero level = 1 milliwatt in 600 ohms

Voltmeter Frequency Range:
10 cps to 100 kc

Voltmeter Accuracy:
Within ±3%, 10 cps to 100 kc

Voltmeter Input Impedance:
Approximately 1 megohm, 37 pf shunt

Noise Measurements:
Full scale reading of 300 microvolts. Noise measuring frequency range, 10 cps to 20 kc. Satisfactory readings can be made to -75 dbm.

Noise Amplifier:
40 db gain ±1 db, 20 cps to 20 kc

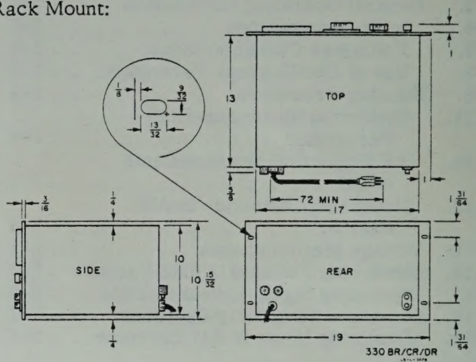
Set Level Amplifier:
20 db gain ±1 db, 20 cps to 20 kc
±2.5 db, 10 cps to 100 kc

Oscilloscope Terminals:
Maximum gain from AF INPUT to oscilloscope terminals is 75 db with full-scale meter deflection.

Power Supply:
115/230 ±10/20 volts, 50-1000 cps, approximately 90 watts

Dimensions:
Cabinet Mount: 12-3/4 in. high, 20-3/4 in. wide, 14-1/4 in. deep

Rack Mount:



Weight:
Cabinet Mount: Net 38 lbs, shipping 58 lbs
Rack Mount: Net 30 lbs, shipping 43 lbs

MODEL 330C

Same as Model 330B except as indicated below:

Voltmeter Frequency Range:
10 cps to 60 kc

Voltmeter Accuracy:
Within ±3%, 10 cps to 20 kc; within ±6%, 10 cps to 60 kc

Set Level Amplifier:
20 db gain ±1 db; 20 cps to 20 kc
±2.5 db; 10 cps to 60 kc

Meter Movement:
VU ballistic characteristics to meet FCC requirements for AM, FM, and TV broadcasting

Carrier Attenuation:
Frequencies 500 kc and above are attenuated at least 40 db in vtvm

MODEL 330D

Same as Model 330C, except:

AM Detector:
Linear AM detector demodulates the transmitted carrier. Tunable from 500 kc to 60 mc in five bands. Distortion introduced by detector is negligible.

SECTION I
GENERAL DESCRIPTION

1-1. INTRODUCTION.

1-2. Models 330C and 330D Distortion Analyzers are shown in figure 1-1. The control panel of the Model 330B is similar to that of the Model 330C.

1-3. The Models 330B, 330C, and 330D measure total distortion at any frequency between 20 cps and 20 kc. The amplitude of an applied voltage containing harmonics is first measured, then the fundamental frequency is suppressed by a sharp tunable filter and the remaining components of the wave are measured. The ratio of the two values is the total distortion, and is indicated on the meter in percent or in decibels. One of the most useful features of the Distortion Analyzer is the provision for monitoring the measurement with an external oscilloscope. The distortion meter-oscilloscope combination provides considerably more information about the device being tested than does a simple expression of the magnitude of the distortion.

1-4. The Distortion Analyzer is also a highly flexible audio-frequency measuring instrument. The instrument can be used to measure the following: 1) audio noise of voltages as small as 100 microvolts, 2) amplifier gain, 3) frequency response in audio equipment, 4) power output levels, and 5) unknown audio frequencies, determining frequency with ±2% or less error. The voltmeter section of the instrument can be used separately for general purpose voltage and gain measurements. The voltmeter is a sensitive wide range vacuum-tube voltmeter with flat frequency response. Voltmeter deflection is proportional to the average value of the incoming signal and is calibrated in terms of the rms of a sine wave. In Models 330C and 330D, the indicating meter has VU ballistic characteristics conforming to FCC requirements for AM, FM, and TV broadcasting.

1-5. In the Model 330D, an amplitude-modulation detector is included in the instrument. The combination of AM detector and distortion analyzer permits the

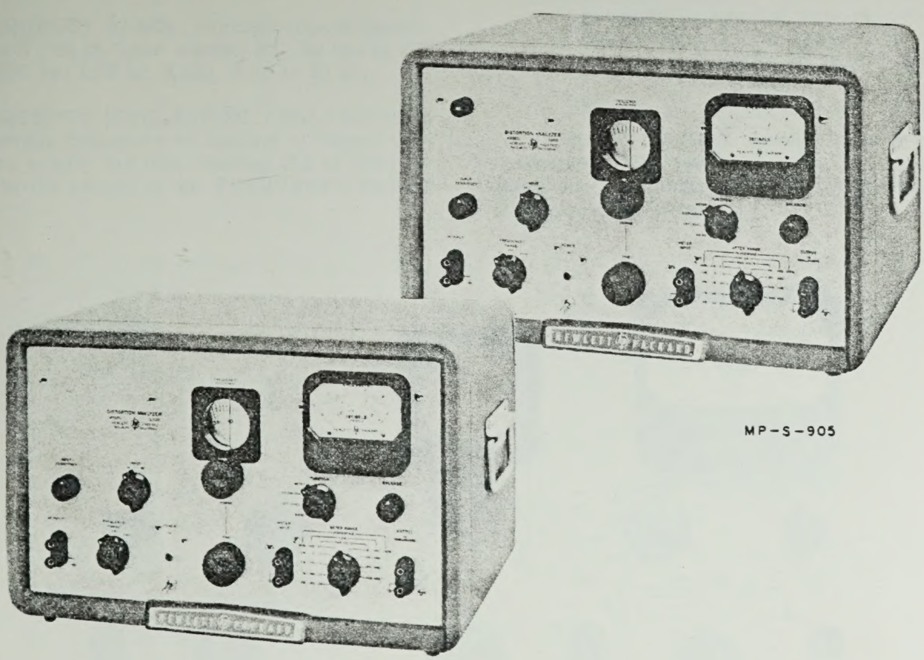


Figure 1-1. Models 330C and 330D Distortion Analyzers

measurement of envelope distortion of an AM carrier. The AM detector is tunable to any rf carrier between 500 kc and 60 mc, and is designed to be coupled loosely to the final tank circuit in an AM transmitter. The detector may be switched out of the circuit when audio frequencies are under measurement. The AM detector assembly may be purchased as an accessory for the Models 330B and 330C.

1-6. UNPACKING AND MECHANICAL INSPECTION.

1-7. Inspect instrument for shipping damage as soon as it is unpacked. If reshipment is expected, save all packing materials to simplify repackaging. Check for broken glass on the meter or tuning dial, broken knobs or connectors. Rotate controls and switches for smoothness of operation. Binding or jamming indicates abnormal mechanical operation. If a control is found that does not turn freely, do not force it; such action may cause permanent damage. Check the electrical performance of the instrument (paragraph 4-49). If instrument is damaged, see the warranty page in this manual.

1-8. 230-VOLT OPERATION.

1-9. The instrument is normally wired for 115-volt operation. To operate the instrument from a 230-volt source, follow the procedure below:

a. Remove two jumpers on terminal strip on under side of chassis, directly beneath power transformer. These jumpers connect the black to the black-green and the black-yellow to the black-red leads of the power transformer primaries.

b. With a new insulated jumper, strap the black-yellow to the black-green lead. (See figure 4-7 or 4-8.)

c. Change the line fuse to a 0.8-ampere slow-blow fuse.

1-10. ELECTRICAL CONNECTIONS.

1-11. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and its case be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

SECTION II
OPERATING INSTRUCTIONS

2-1. INTRODUCTION.

2-2. This section contains general operating information and operating procedures for the Models 330B, 330C, and 330D.

2-3. CONTROLS AND INDICATORS.

2-4. The functions of the controls and indicators are described below. The controls and indicators are shown in Figures 2-1 and 2-2.

a. POWER toggle switch. Turns on line power to instrument.

b. POWER ON indicator. Lights when the instrument is turned on.

c. INPUT AF-RF selector switch. Models 330B, 330C only: Selects af signal from the AF INPUT or the AF-RF INPUT binding posts. Model 330D only: When the switch is set at RF, the signal from the AM detector is applied to an amplifier.

d. INPUT SENSITIVITY control. Adjusts the input level of the applied signal in any position of the FUNCTION switch except the METER position.

e. FREQUENCY RANGE. For distortion measurements, select one of three bands: X1, 20 cps to 200 cps; X10, 200 cps to 2 kc; X100, 2 kc to 20 kc.

f. FREQUENCY (CYCLES/SEC.) dial. Indicates the fundamental frequency of applied af signal with ±2% or less error; the dial reading (20 to 200) is multiplied by the setting of the FREQUENCY RANGE switch.

g. COARSE frequency tuning knob. Provides for coarse adjustment of tuning dial.

h. FINE frequency tuning knob. Provides for vernier adjustment of tuning dial.

i. FUNCTION switch. Selects various sections of the instrument to perform the following functions:

(1) NOISE. Provides a gain of 40 db maximum from input to vtvm input. This arrangement allows noise voltages as low as 100 microvolts to be read over the entire audio spectrum.

(2) SET LEVEL. This position is used in distortion measurements for establishing a reference level. Also provides a gain of 20 db maximum from input to vtvm input for measuring low signal levels.

NOTE

A minimum of 1.0 volt rms is required to measure 100% distortion.

(3) DISTORTION. Adjusts equipment to measure total harmonic content of applied signal.

(4) METER. Allows voltmeter to be used independently for general purpose voltage and gain measurements. The signal to be measured is applied to the METER INPUT binding posts.

NOTE

Maximum rms input is 5.0 volts.

j. METER RANGE switch. Selects the range in percentage, db, and rms volts. The designation on each position states the value of the full-scale deflection of the meter.

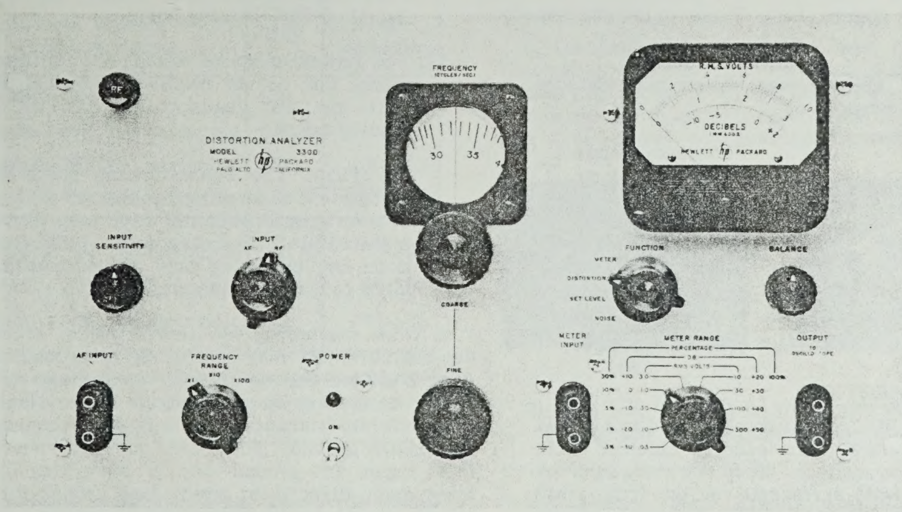


Figure 2-1. Front-Panel Controls, Model 330D

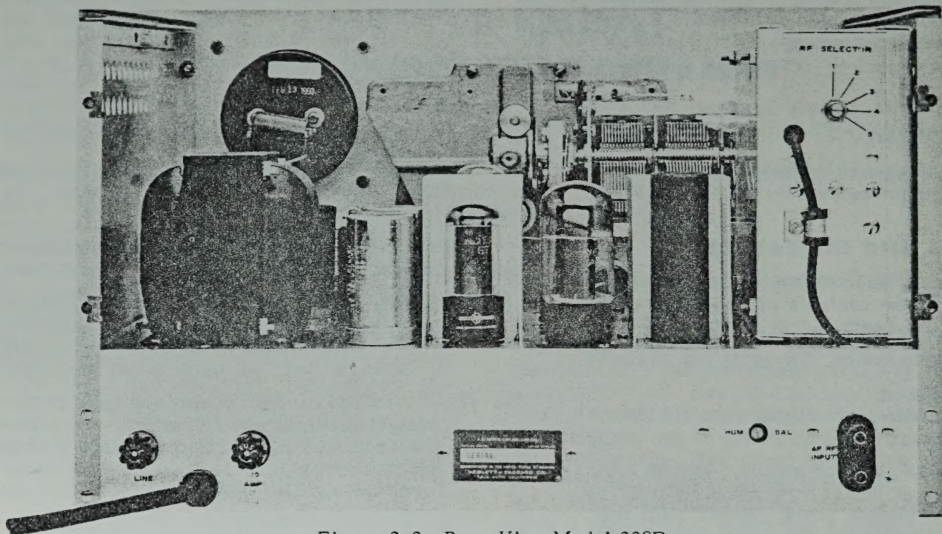


Figure 2-2. Rear View Model 330D

k. Meter. Indicates on desired scale; read METER RANGE switch designations as full-scale indication.

m. BALANCE. Adjusts equipment to obtain minimum meter reading with FUNCTION switch set at DISTORTION.

n. HUM BAL adjustment (on rear of instrument; see figure 2-2). Adjusted to minimize internally-generated noise.

p. In Model 330D only, two additional controls are included in the instrument.

(1) RF control (figure 2-1). Tunes to the carrier frequency.

(2) RF SELECTOR (on rear; figure 2-2). Selects one of five bands:

Position	Frequency Range
1	500 kc to 1.3 mc
2	1.3 mc to 3.4 mc
3	3.4 mc to 8.8 mc
4	8.8 mc to 19.5 mc
5	19.5 mc to 60 mc

2-5. GENERAL OPERATING INFORMATION.

2-6. INPUT CONNECTIONS.

a. ⓗⓟ Model 330B/C/D can be connected to a signal source through twisted pair leads or shielded cable with banana plug connectors. Keep test leads as short as possible to avoid extraneous pickup from stray ac fields. Do not connect circuit potential greater than 400 volts across AF INPUT binding posts or greater than 600 volts across METER INPUT binding posts. Higher voltage will break down the input capacitors. For instruments equipped with an rf detector unit, do not apply rf voltages greater than 50 volts.

b. Make input connections as follows:

(1) For af distortion measurements, connect the test leads to the AF INPUT binding posts. For envelope distortion measurements, connect the test leads to the AF-RF INPUT binding posts.

(2) For noise, signal level, and gain measurements requiring amplification, connect test leads to the AF INPUT binding posts.

(3) For general purpose voltage and gain measurements that do not require amplification, connect the test leads to the METER INPUT binding posts.

CAUTION: The black binding posts and the instrument case will be connected to the power system ground when the instrument is used with a standard NEMA receptacle. Avoid short circuits by connecting only ground potential circuits to the black binding posts.

c. When measuring low-level signals, accuracy of the measurement may be affected by ground current. A ground loop can be completed via the ground conductor of the signal pair and the power-line ground when the instruments in a setup are connected to power-line ground. To restore accuracy of measurement, open the ground loop by connecting only one instrument directly to power-line ground through a NEMA (three-prong) connector. Connect any other instrument in the setup to the power source through an ungrounded adapter. See figure 2-3.

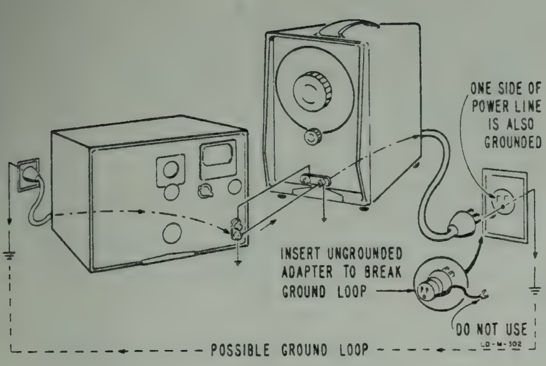


Figure 2-3. Breaking a Ground Loop

2-7. VOLTMETER CHARACTERISTICS.

a. The R. M.S. VOLTS markings on the meter face are based on the ratio which exists between the average and effective (rms) values of a pure sine wave. The ratio of average to effective values in a true sine wave is approximately 0.9 to 1. However, when the meter is used to measure complex waves, the voltage indicated may not be the rms value of the signal applied. This deviation of meter indication exists because the ratios of average to effective values are usually not the same in a complex wave as in a sine wave. The degree of variation depends on the magnitude and phase relation between harmonics and fundamental of the signal applied. Table 2-1 shows the deviation of the meter indication of a sine wave partly distorted by harmonics. As indicated in table 2-1, harmonic content of less than approximately 10% results in very small errors.

Table 2-1. Effect of Harmonics on Voltage Measurements

Input Voltage Characteristics	True RMS Value	Meter Indication
Fundamental = 100	100	100
Fundamental +19% 2nd harmonic	100. 5	100
Fundamental +20% 2nd harmonic	102	100-102
Fundamental +50% 2nd harmonic	112	100-110
Fundamental +10% 3rd harmonic	100.5	96-104
Fundamental +20% 3rd harmonic	102	94-108
Fundamental +50% 3rd harmonic	112	90-116

Note: This chart is universal in application since these errors are inherent in all average-responding type voltage-measuring instruments.

b. In distortion measurements, where the fundamental frequency is suppressed and the remainder of the wave is measured, the reading obtained on an average-responding meter may deviate from the true total rms value. When the residual wave contains many inharmonically related sinusoids, the maximum error in the distortion reading is about 11% low*. For example:

Measured Distortion	Maximum Error in Meter Indication	Total Distortion
2.5%	+0.11 x 0.025 = 0.0027	0.025 + 0.0027 = 0.0277 or 2.8%

The foregoing example represents maximum possible error and in most cases this error is less. In general, in distortion measurements, the reading of an average-responding meter is sufficiently close to the rms value to be satisfactory under most measurement conditions.

2-8. USE OF OSCILLOSCOPE TERMINALS.

a. One of the most useful features of the distortion analyzer is the provision for meter output terminals. They are provided so that the distortion meter may be used with an oscilloscope. The combination of the distortion meter and the oscilloscope provides much more significant information about the device under test than the expression of distortion magnitude.

b. When the residual wave is applied to the vertical input of an oscilloscope and the source signal is applied to the horizontal input, a stationary pattern is obtained. Information obtained from this pattern is specific and reveals the nature of the distortion which sometimes occurs at such low levels that it is difficult to detect in the presence of hum and noise.

c. Grid current being drawn will produce a sharp notch in the wave (one if the signal source is single ended and two if it is operated push-pull). Parasitic oscillations show up as rf bursts on the waveform or, when the oscillations are of too high frequency to be passed, as sharp breaks. Transient oscillations can be caused by saturation of iron in the circuit, continuous oscillations by an unfavorable gain phase shift characteristic.

d. Oscillograms illustrating type of information obtainable with distortion meter-oscilloscope combination are shown in figure 2-4. Figure 2-4A shows a sine wave with approximately 1.5% distortion. Figure 2-4B shows oscilloscope presentation obtained

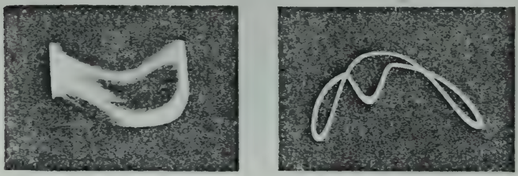
(A) (B)

Figure 2-4. Typical Oscillograms Obtained with Distortion Meter-Oscilloscope Combination

* B.M.Oliver, "Some Effects of Waveform on VTVM Readings", Hewlett-Packard Journal, Volume 6, No. 9-10, May-June, 1955.

while measuring the distortion. This presentation displays the actual distortion components, consisting mainly of second harmonic but which also include a transient oscillation. Such oscillations, often undetected unless an oscilloscope is used during measurement, indicate an unstable system and are often themselves unstable, varying with driving level, frequency, etc.

f. Figure 2-5 shows oscilloscope presentation obtained (A) while measuring distortion in amplifier where distortion level is of same order of magnitude as hum, and (B) while measuring distortion in amplifier driven at point of overload. Notch in pattern is caused by small grid current and will increase sharply with small increase in drive.



(A) (B)

Figure 2-5. Typical Oscillogram, Amplifier Distortion

2-9. STARTING PROCEDURE.

2-10. Perform the starting procedure given below before using the operating procedure.

a. Preliminary. Set front-panel controls as follows:

(1) POWER toggle switch to off position.

(2) INPUT SENSITIVITY control fully counterclockwise.

(3) METER RANGE switch to approximate level to be measured. If approximate level is not known, set at +50 DB.

b. Starting.

(1) Set POWER switch to ON, and allow approximately 5 minutes warmup.

(2) Check zero setting of meter. When meter is properly zero-set, pointer rests over the zero calibration mark on the 0-1 meter scale when instrument is a) at normal operating temperature, b) in its normal operating position, and c) turned off. If adjustment of zero-set is required refer to paragraph 4-27.

2-11. DISTORTION MEASUREMENT IN PERCENTAGE.

a. Connect test leads from signal source to AF INPUT binding posts. For Models 330B and 330C, AF-RF INPUT binding posts on rear of instrument may be used. Set signal source for desired signal frequency.

b. Set front-panel controls as follows:

(1) INPUT AF-RF switch to AF. Models 330B, 330C only: switch to RF if rear AF-RF INPUT terminals are used.

(2) FUNCTION switch to SET LEVEL.

(3) METER RANGE switch to 100%.

c. Turn INPUT SENSITIVITY control clockwise until meter pointer reaches full-scale deflection of exactly 1.0.

d. Set FREQUENCY RANGE switch to the position which includes fundamental frequency of signal source. The bands are as follows: X1, 20 to 200 cps; X10, 200 to 2000 cps; X100, 2 to 20 kc.

e. Turn FUNCTION switch to DISTORTION.

f. Adjust FREQUENCY COARSE control until meter pointer drops sharply.

g. Adjust FREQUENCY FINE control for maximum dip of meter pointer; if at low end of meter scale, decrease setting of METER RANGE switch.

h. Adjust BALANCE control for a minimum meter reading.

i. Readjust FREQUENCY FINE and BALANCE controls until no further reduction in meter reading can be obtained. As adjustment progresses, decrease setting of METER RANGE switch to maintain upscale meter deflection.

j. Distortion measured is read on the meter in conjunction with METER RANGE switch. For example, if meter indicates 1.5 and METER RANGE switch is on 3% position, distortion measured is 1.5%.

2-12. AF DISTORTION MEASUREMENTS IN DB.

a. Set front-panel controls as follows:

(1) METER RANGE to +20 DB.

(2) FUNCTION to SET LEVEL.

(3) INPUT AF-RF to AF. (When connection to Models 330B, 330C is to rear AF-RF INPUT terminals, set to RF.)

b. Connect test leads from signal source to AF INPUT terminals. Set source for desired signal frequency.

c. Adjust INPUT SENSITIVITY control until meter pointer is on 0 decibels.

d. Follow steps d through i given in paragraph 2-11.

e. DB distortion measurements are obtained by algebraically adding minus 20 db and the DB range setting to the value indicated on the meter. Examples of typical db distortion measurements:

DB setting of METER RANGE	Meter Reading	DB Distortion Measured
-20	-6 db	46 db below +20 db level
-30	+1 db	49 db below +20 db level
0	-1.5 db	21.5 db below +20 db level

2-13. MEASURING DISTORTION IN AM CARRIER.

NOTE

The following procedure applies to the Model 330D or a Model 330B/C that has been modified to include an AM detector unit.

a. After turning on instrument set controls as follows:

(1) INPUT SENSITIVITY 3/4 clockwise.

(2) INPUT AF-RF to RF.

(3) FREQUENCY RANGE to the position which includes the frequency of the modulating signal.

(4) FUNCTION to SET LEVEL.

(5) METER RANGE to +30 DB.

b. Turn RF SELECTOR switch (located on upper rear of instrument) to the position which includes the transmitter carrier frequency. Ranges are as follows:

Position	Frequency Range
1	500 kc to 1.3 mc
2	1.3 mc to 3.4 mc
3	3.4 mc to 8.8 mc
4	8.8 mc to 19.5 mc
5	19.5 mc to 60 mc

c. With test leads, connect rf coupling coil in the transmitter to the AF-RF INPUT terminals. This coupling is made, in general, to the transmitter final amplifier plate tank coil, and provision is usually made by the transmitter manufacturer for this connection.

CAUTION

Do not apply rf voltage which exceeds 50 volts to AF-RF INPUT terminals. Higher voltages will damage the AM detector circuit.

d. Modulate the rf carrier 30% with fixed af test tone.

e. Adjust the degree of coupling between transmitter and distortion analyzer. RF voltage of approximately 11 volts is sufficient for this measurement.

f. On the 330D, turn RF knob for maximum meter deflection. If necessary, change setting of METER RANGE switch to maintain up-scale meter deflection.

g. Set METER RANGE switch to 100%; readjust rf coupling to obtain full-scale meter deflection on 0 to 1 scale.

h. Modulate the rf carrier to the desired percentage and measure distortion in percent or db (see paragraph 2-11 or 2-12).

2-14. VOLTAGE MEASUREMENTS.

2-15. The Model 330 is so arranged that signals can be applied directly to the voltmeter section or, where increased sensitivity is required, to the internal amplifier before being passed to the voltmeter.

Table 2-2. Voltage and Decibel Ranges of Voltmeter

METER RANGE position		Meter Reading	
RMS VOLTS	DB	Voltage Range	Decibel Range
.03	-30	0 to 0.03	-28 to -42
.1	-20	0 to 0.10	-18 to -32
.3	-10	0 to 0.30	-8 to -22
1	0	0 to 1.00	-12 to +2
3	+10	0 to 3	-2 to +12
10	+20	0 to 10	+8 to +22
30	+30	0 to 30	+18 to +32
100	+40	0 to 100	+28 to +42
300	+50	0 to 300	+38 to +52

a. Direct. Ranges are shown in table 2-2, signal is applied to METER INPUT terminals, FUNCTION selector is set to METER. These controls are ineffective: INPUT AF-RF, INPUT SENSITIVITY, FREQUENCY RANGE, and both FREQUENCY controls. For the 330B, voltmeter frequency range is 10 cps to 100 kc; for the 330C/D, from 10 cps to 60 kc. Procedures: see paragraphs 2-16 and 2-17.

b. Through Internal Amplifier. Two degrees of increased sensitivity (at a sacrifice in bandwidth) are provided; for both, signal is applied to AF INPUT terminals. See table 2-3 and paragraph 2-18.

2-16. MEASURING VOLTAGES IN RMS VALUES.

a. Connect test leads from signal source to METER INPUT terminals.

b. Set FUNCTION switch to METER.

c. Increase or decrease setting of METER RANGE switch to obtain readable meter deflection.

d. Read indicated voltages on 0-1 or 0-3 scale of meter; METER RANGE designations show value at full-scale deflection.

2-17. MEASURING SIGNAL LEVELS IN DBM.

a. Follow procedure given in paragraph 2-16a,b.

b. Set METER RANGE switch to DB position which gives a readable meter indication.

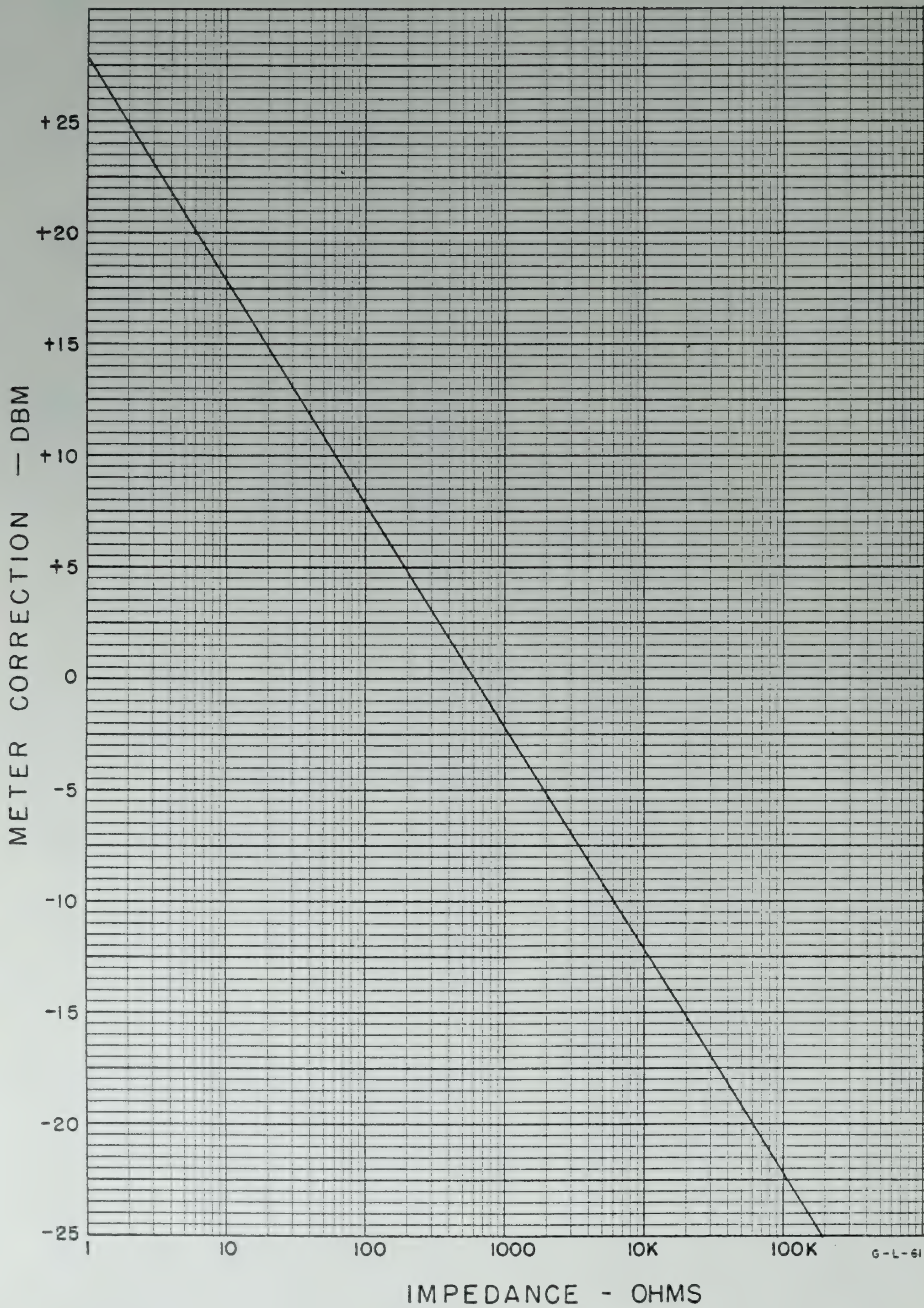


Figure 2-6. Impedance Correction Graph

Table 2-3. Operation at Increased Sensitivity

Model	FUNCTION Selector	Range of Input Levels (dbm)	Frequency Range	Gain	Divide Voltmeter Reading
330B	SET LEVEL	-62 to 0	20 cps - 20 kc	20 db ± 1 db	by 10
			10 cps - 100 kc	20 db ± 2.5 db	
	NOISE	-75 to -20	20 cps - 20 kc	40 db ± 1 db	by 100
330C/D	SET LEVEL	-62 to 0	20 cps - 20 kc	20 db ± 1 db	by 10
			10 cps - 60 kc	20 db ± 2.5 db	
	NOISE	-75 to -20	20 cps - 20 kc	40 db ± 1 db	by 100

c. If the impedance of the signal source is 600 ohms, the dbm level is the algebraic sum of the meter indication and the setting of the METER RANGE switch. For example, METER RANGE is on -20 DB, meter indicates +2 DECIBELS, the dbm level is -18.

d. If the impedance of the signal source is other than 600 ohms, the dbm level is obtained by applying a correction factor to the algebraic sum of meter indication and setting of METER RANGE switch. To find correction factor, refer to Impedance Correction Graph shown in figure 2-6.

In figure 2-6, find the intersection of the impedance of the signal source and the diagonal line. Read the correction factor on the vertical axis. Examples:

(1) If the measurement is made across 90 ohms, the indication on the DECIBEL scale is +2, and the METER RANGE switch is at +20 DB, the level in dbm is obtained as follows:

+2 (meter indication)
+20 (METER RANGE position)
+22 (sum)
+8 (correction factor from figure 2-6)
+30 dbm

(2) For the same conditions as given above, except that the measurement is made across an impedance of 60,000 ohms, the level in dbm is obtained as follows:

+2 (meter indication)
+20 (METER RANGE position)
+22 (sum)
-20 (correction factor from figure 2-6)
+2 dbm

2-18. INCREASED SENSITIVITY OPERATION.

2-19. When the FUNCTION switch is at SET LEVEL, the sensitivity of the vtvm is increased by a voltage gain of 10; at NOISE, the sensitivity of the vtvm is increased by a voltage gain of 100. See table 2-3.

a. Connect test leads from signal source to be measured to AF INPUT terminals.

b. Set INPUT SENSITIVITY control maximum counterclockwise.

c. Set INPUT AF-RF selector to AF.

d. Set FUNCTION switch to SET LEVEL or to NOISE.

e. Set METER RANGE switch to 10 RMS VOLTS.

f. Slowly turn INPUT SENSITIVITY control clockwise and note meter reading. If the reading exceeds 10 volts before the control is turned maximum clockwise, do not use the increased sensitivity facilities. Obtain rms voltage reading as described in paragraph 2-16 or dbm reading as described in paragraph 2-17.

g. With INPUT SENSITIVITY control maximum clockwise, adjust setting of METER RANGE switch to obtain a readable meter deflection.

h. To obtain rms value of the voltage being measured, divide indicated voltage by 10 with FUNCTION at SET LEVEL, by 100 with FUNCTION at NOISE.

i. To obtain the dbm value, algebraically add -20 dbm to the indicated level with FUNCTION at SET LEVEL, add -40 dbm with FUNCTION at NOISE. Examples:

Setting of METER RANGE	Meter Reading	Actual Value
.03	2	
	(SET LEVEL)	0.002 volt
	(NOISE)	0.0002 volt
-20 DB	-1	
	(SET LEVEL)	-41 dbm
	(NOISE)	-61 dbm

2-20. MEASURING NOISE IN AM CARRIERS.

2-21. The following procedure applies to Model 330D or a Model 330B/C that has been modified to include the AM detector unit.

a. Follow the procedure given in paragraph 2-13, steps a through g.

b. Modulate the rf carrier 100% with a fixed test tone.

c. Adjust INPUT SENSITIVITY control until meter pointer is on 0 DECIBELS.

d. Remove modulation from rf carrier.

e. Turn FUNCTION switch to NOISE position.

f. Decrease setting of METER RANGE switch to obtain readable meter deflection. Do not disturb the setting of INPUT SENSITIVITY control.

g. To obtain the level of the noise being measured, algebraically add -20 db to the difference between the readings obtained in step c and that obtained in step f. For example, if the final meter reading is -6 DECIBELS with the METER RANGE switch in the -20 DB position, the noise level is computed as follows:

+20 db (meter reading with 100% modulation)
-26 db (meter reading with no modulation)

-46 db (difference in two meter readings)
-20 db (correction factor)(difference in gain between SET LEVEL and NOISE settings of FUNCTION)
-66 db below 100% modulation

SECTION III
THEORY OF OPERATION

3-1. INTRODUCTION.

3-2. The Model 330B/C/D consists of three major circuits: a selective amplifier, a vacuum-tube-voltmeter circuit, and a power supply. The amplifier and voltmeter are shown in block diagram form in figure 3-1.

3-3. SELECTIVE AMPLIFIER.

3-4. The selective amplifier circuit consists of a three-stage preamplifier, a Wien bridge, and a bridge amplifier.

3-5. The signal to be measured is applied to the preamplifier through AF INPUT, INPUT AF-RF, or (in the 330D) through the AM detector unit. The output of the preamplifier is applied to the Wien bridge.

3-6. The circuit is arranged so the Wien bridge can be switched in or out of the circuit.

a. When the bridge is in the circuit, it is tuned to reject the fundamental frequency, leaving the remaining components of the wave to be amplified by the bridge amplifier. The Wien bridge is responsive to input signals with fundamental frequencies of from 20 to 20,000 cps.

b. When the bridge is out of the circuit, the two amplifiers provide up to 20- or 40-db gain for the vtvm circuit. When the FUNCTION switch is set to SET LEVEL, the combination of preamplifier and bridge amplifier provides a voltage gain of 10 or gain of 20 db. When the FUNCTION switch is set to NOISE, the gain of the two amplifiers provides a voltage gain of 100 or gain of 40 db. In the NOISE position, noise voltages as low as 100 microvolts can be read over the entire audio spectrum.

3-7. When the instrument is used for making distortion measurements, a reference reading is first obtained (on the meter in the vtvm circuit) with the Wien bridge out of the circuit. Then the bridge is switched into the circuit and is tuned to reject the fundamental frequency, thus allowing residual voltages to be measured. The METER RANGE switch in the vtvm circuit is arranged so that the distortion, the ratio of the two voltmeter readings, can be read directly in percent or in db.

3-8. WIEN BRIDGE.

3-9. Suppression of the fundamental-frequency component in the applied wave is obtained by the use of a tunable Wien bridge circuit. When FUNCTION switch S4 (see figure 4-9) is set at DISTORTION, the bridge

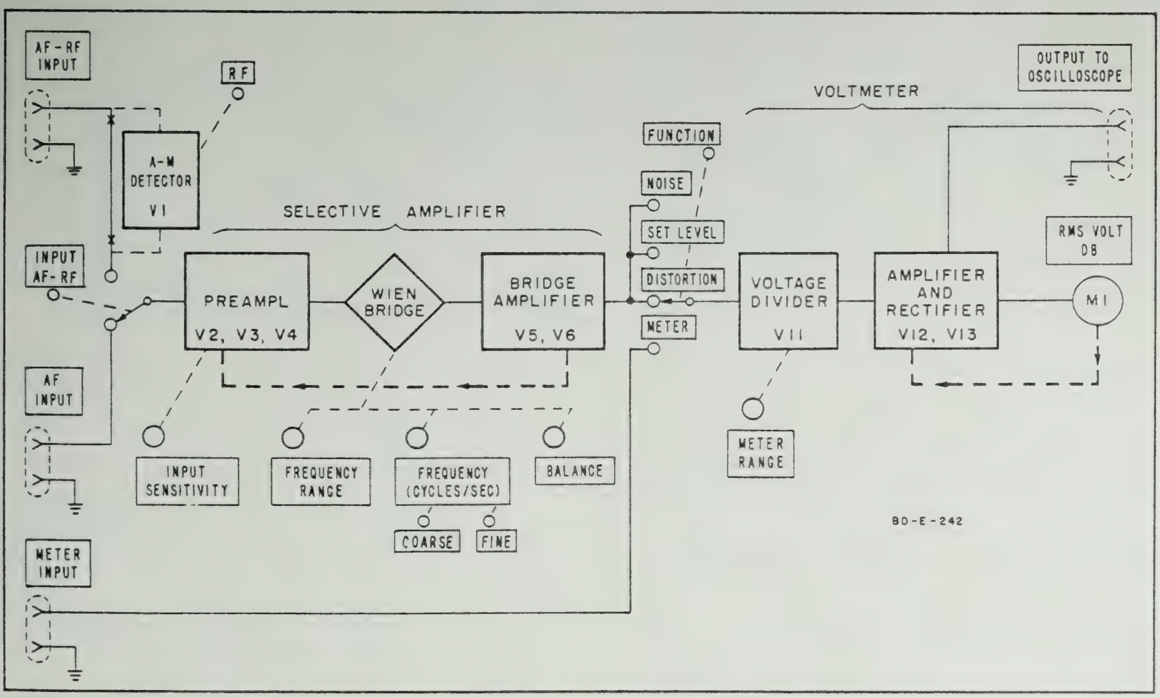


Figure 3-1. Block Diagram

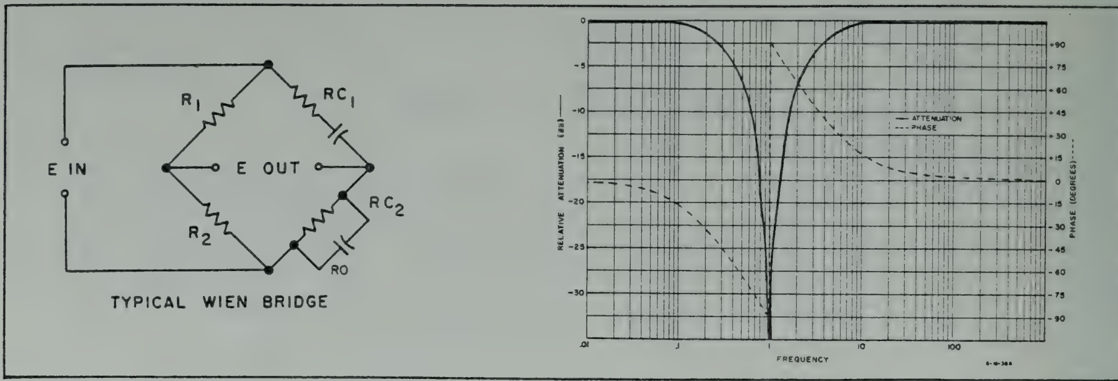


Figure 3-2. Amplitude and Phase Characteristics of the Wien Bridge

is connected as an interstage coupling network between V4 and V5. The bridge is brought into balance by adjusting C13 and BALANCE control R23. When the bridge is balanced, the voltage and the phase of the fundamental, which appears at the junction of the series reactive arm and the shunt reactive arm of the bridge, are the same as at the midpoint of the resistive branch. Since these two voltages are equal and in phase, no output appears at the plate of V5. However, for the remainder of the wave the reactive branch of the bridge offers various degrees of attenuation and phase shift, and V5 amplifies the various voltages which exist at its cathode and grid. It can be noted from figure 3-2 that the rejection characteristic of the bridge for harmonic voltages is not constant. Typically, the second harmonic will be attenuated several db more than the third, the third more than the fourth, etc. To correct for this broad rejection response, a negative feedback loop is connected around the bridge. The negative feedback path is from the cathode of V6 (output of the bridge amplifier) to the cathode of V2 (first preamplifier stage). The resultant second harmonic is attenuated less than 1.5 db for fundamental frequencies in the 20-cps to 5-kc range; less than 3 db for fundamental frequencies in the 5-kc to 20-kc range. Typical frequency rejection characteristic of the distortion analyzer is shown in figure 3-3.

3-10. The bridge is designed to cover a continuous frequency range of 10 to 1. This range is extended by the FREQUENCY RANGE switch which changes the bridge constants in three decade steps, providing tuning to cover the complete audio frequency range (20 to 20,000 cps).

3-11. When FUNCTION switch S4 is set to the SET LEVEL or NOISE position, the junction of the series reactive arm and shunt reactive arm of the bridge is shorted to ground, disabling the frequency-rejection characteristic of the bridge. In these positions, V5 is converted to a grounded-grid amplifier, and provides amplification for signals prior to measurement on the voltmeter.

3-12. VOLTMETER CIRCUIT.

3-13. The voltmeter section (see figures 4-7 and 4-8) consists of a voltage-divider stage, a two-stage wideband amplifier, and a meter-rectifier circuit.

3-14. The voltage-divider stage is a cathode follower (V11) with a seven-tap precision resistor in its cathode circuit. The ratio between taps is 3.16 to 1 or 10 db. Each of the taps is connected to switch contacts on METER RANGE switch S6. On the 100 and 300-volt ranges, a compensated voltage divider is switched into the input of voltage-divider stage V11.

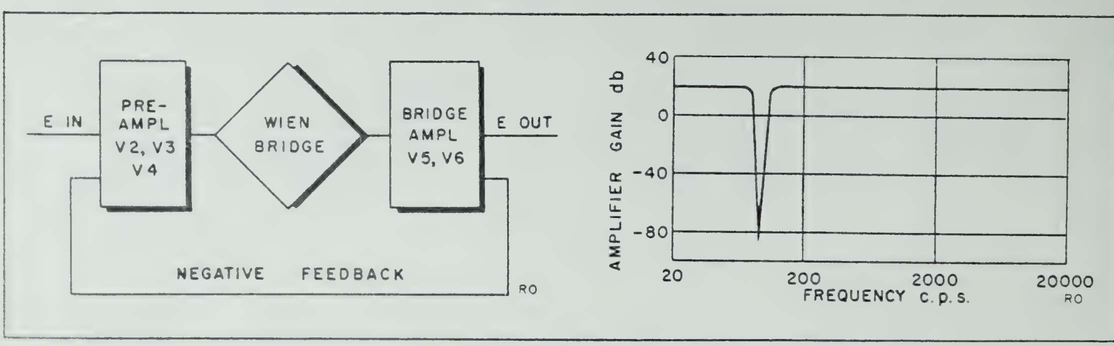


Figure 3-3. Typical Frequency-Rejection Characteristic of Distortion Analyzer

3-15. Amplification of the signal voltage from METER RANGE switch S6 is provided by a two-stage wide band amplifier, V12 and V13. A high level of negative feedback is used to insure stability and a flat frequency response over a wide frequency band. The feedback path is from the plate of V13, through the meter-rectifier circuit, to the cathode of V12.

3-16. The meter-rectifier circuit is arranged to serve two functions: a) deliver pulsating direct current to the meter and b) deliver alternating current of the same frequency as the current at the input to the cathode circuit of V12. The meter-rectifier circuit is a bridge-type configuration, with a silicon diode and a resistor in each branch and a dc milliammeter connected across its midpoints. The diode connection provides full-wave rectification of the current to meter M1. Meter M1 is calibrated to indicate the rms value of a pure sine wave applied to the input. The output of V13 is also connected to the OUTPUT TO OSCILLOSCOPE binding posts. This output is designed to be connected only to high-impedance devices such as oscilloscopes.

3-17. A direct voltmeter input, the METER INPUT binding posts (see figure 4-9), allows the voltmeter circuit to be used independent of the selective amplifier.

3-18. AM DETECTOR.

3-19. An AM detector unit is included in the Model 330D. With this combination, envelope distortion in AM carrier can be measured directly. The AM detector unit is designed to be coupled loosely to the final tank circuit of an AM transmitter.

3-20. The detector (figure 4-9) consists of a resonant circuit, shunt diode detector V1, and a low-pass filter. Switch S1, located on the instrument rear, selects any of five rf bands from 500 kc to 60 mc. The circuit is tuned for resonance at the carrier frequency by the RF control knob. Diode V1 recovers the modulating signal from the rf carrier with minimum distortion. The low-pass filter removes any rf components from the modulating signal before it is applied to the selective amplifier circuit.

3-21. The input for the detector unit is the AF-RF INPUT binding posts located at the rear of instrument. With INPUT AF-RF switch S2 at RF, the 330D accepts the af signal from the output of the detector; with the switch at AF, the 330D accepts the af signal from the AF INPUT binding posts.

3-22. POWER SUPPLY.

3-23. The power supply circuit (figures 4-7, 4-8) includes power transformer T1, full-wave rectifier V7, series regulator V8, regulator amplifier V9, and voltage reference V10. Unregulated B+ voltage (after the filter section) is supplied to the voltmeter circuit and to the plate of series regulator V8.

3-24. The cathode of V8 supplies regulated B+ to the amplifier circuit. Series regulator V8 serves as an adjustable impedance controlled by amplifier V9. Amplifier V9 samples the regulated voltage and amplifies any difference between it and the reference voltage provided by V10, a glow-discharge tube. The sample of regulated output is obtained from a voltage divider consisting of R42, R43, and R44. Potentiometer R43 is adjusted to provide an output voltage of +225 volts at the cathode of V8.

3-25. Voltage comparison is accomplished by applying the sampled voltage to the grid of V9 and the reference voltage to the cathode of V9. If output voltage tends to increase, V9 amplifies this increase and applies it in opposite phase to the grid of V8 causing the impedance of V8 to increase. This increased impedance lowers the output B+ voltage. Thus the voltage change responsible for this sequence is counteracted. The reverse takes place when the output B+ voltage tends to decrease.

SECTION IV
MAINTENANCE

4-1. INTRODUCTION.

4-2. This section contains maintenance information for the distortion analyzer. The troubleshooting procedures described herein are intended to first isolate a malfunction to a particular section of the instrument and then localize the malfunction to a particular stage or circuit within the section. In most instances, instrument failure will be due to defective electron tubes. The instrument can then be returned to service by replacing the defective tube and performing the check and/or adjustment as outlined in table 4-2.

4-3. A front-panel check which provides a quick method of isolating most failures to one of three major sections of the distortion analyzer without the use of external test equipment is given in table 4-1. Though this check will not detect marginal malfunctions or error in calibration, it is particularly helpful in locating defective electron tubes.

4-4. CABINET REMOVAL.

a. Remove screws from the rear cover of the instrument.

b. Remove the rear cover.

c. Being careful to prevent damage to the fuse cartridge holders which are projecting from the rear chassis, place instrument on its back with the control panel up.

d. Loosen two setscrews on the bottom of the cabinet adjacent to each front foot. These screws anchor the cabinet to the front panel.

e. Lift the cabinet from the instrument.

4-5. PERIODIC INSPECTION AND MAINTENANCE.

CAUTION

Do not disturb the setting of the rotor plates of tuning capacitor C13. Even a slight change in plate alignment results in loss of frequency calibration. Avoid changing positions of wiring and adjustable components. Do not disturb any of the alignment adjustments unless it definitely has been determined that the trouble is caused by misadjustment.

4-6. Inspect for any physical damage or deterioration; correct same in accordance with good maintenance practices. The only periodic maintenance required is lubrication of the frequency-tuning mechanism.

a. Lubricate the frequency tuning mechanism every six months with light machine oil such as MIL-L-6086 Grade L. Be sure that points to be lubricated (and lubricants) are clean and free from sand, grit, or dirt. Use lint-free cloth to remove any foreign matter.

b. Lubrication: add one or two drops to the idler shaft, coupler drive shaft, and drive shaft every six months.

4-7. REPLACEMENT OF ELECTRON TUBES.

4-8. Before removing tubes from the instrument, mark each tube so it can be returned to its original socket. Any tube with corresponding EIA characteristics can be used as replacement. However, some tube positions in the distortion analyzer require tubes which are free of certain faults. For greatest reliability, use replacement tubes which have been aged and which have been tested in the circuit they are to be used in. Remember that most tube failures occur during the first 100 hours of operation. After this period, tubes age slowly. Replace a tube if it fails; don't replace it prematurely as part of routine maintenance. Most tube testers check only certain tube parameters under limited service; they are not reliable indicators of tube usefulness in complex circuits. New tubes can check "good" in such testers, yet exhibit such characteristics as low transconductance with low line voltage, excessive grid current with high line voltage, too low or too high cathode current, heater-to-cathode leakage, microphonics, and intermittent malfunctions. Such troubles are most often detected while the tube is being used in the instrument while making critical measurements. If a tube tester is used and it indicates a good tube, consider the indication only semi-final; if it indicates a bad tube, consider the indication final. You can obtain final proof of satisfactory performance only by operating the tube in its intended circuit while making a critical measurement. To locate a defective tube, proceed as follows:

a. Determine if the source of trouble lies in the voltmeter, amplifier or power supply section. Defective tubes in the power supply section degrade performance of both amplifier and voltmeter sections.

b. Substitute a good tube for a suspected tube one at a time in the particular section. For each new tube tried, note instrument performance. If possible, set line voltage to 103 volts and measure distortion present in a low-distortion audio oscillator, such as ⓗⓟ Model 206A; look for irregularities in operation and performance such as instability, excessive reading, excessive residual meter reading with no signal applied to the input, microphonics, etc. Repeat, using 127 volts line voltage. Watch for the possible disappearance of some trouble symptoms and the appearance of new symptoms. Replacement tube must operate satisfactorily over this range of line voltage.

c. If a new tube seems to improve instrument operation, keep the old tube for a repeat test to see if it will again produce the symptom. Do not discard tubes rejected for the use in the distortion analyzer because

of marginal malfunction. Such tubes are often useful in applications which are not sensitive to the exhibited disorder.

d. If the distortion analyzer shows a change in performance when a tube is replaced, but still does not operate satisfactorily, another trouble may exist which may be related to the replaced tube. Measure the voltages on the tube socket contacts and compare them with the corresponding voltages on the schematic diagram. The compared voltages should be well within 20% of each other as measured with an accurately calibrated voltmeter.

e. If a tube is replaced, perform the necessary check and/or adjustment as indicated in table 4-2.

4-9. REQUIRED TEST EQUIPMENT.

4-10. Test equipment required for maintaining the instrument is listed in table 4-3. Equipment of similar characteristics may be used in lieu of those listed.

4-11. POWER SUPPLY.

4-12. The power supply in the distortion analyzer must function correctly before the instrument will operate properly. Noise or excessive variations in

Table 4-2. Tube Replacement

Tubes	Check or Adjustment
V1 (330D only)	No adjustment
V2, V3, V4, V5, and V6	Internal amplifier gain; residual reading (paras 4-44, 4-45). If V5 is replaced, also check Wien bridge circuit and frequency dial calibration (para. 4-46).
V7, V8, V9, and V10	Check stability of dc voltage with changes in line voltage (para. 4-12). If regulated supply requires adjustment refer to para. 4-34.
V11, V12, and V13	Check calibration and frequency response of voltmeter. (For Model 330B refer to paras 4-38 and 4-40; for Models 330C and 330D refer to paras. 4-38 and 4-42.)

Table 4-3. Test Equipment Required

Instrument Type	Required Characteristic	Use	Instrument Recommended
Electronic Counter or Frequency Standard and an Oscilloscope	Frequency measurement from 20 to 20,000 cps Sinusoidal frequency standard output frequencies: 10 cps, 100 cps, 1 kc, and 10 kc	Frequency dial calibration	hp 521 series, 522B, 523B/C/D, or 524B/C/D hp 100 series and hp Model 120A, 122A, or 130A/B Oscilloscope
Electronic DC Voltmeter	Voltage range: 1 volt to 1000 volts Input Resistance: at least 100 megohms	Voltage and resistance measurements	hp Model 412A or hp Model 410B
Electronic AC Voltmeter	Voltage range: 0.001 to 300 volts fs Input resistance: 10 megohms Frequency range: 10 cps to 4 mc Voltmeter accuracy: within ± 1% of full scale from 50 cps to 500 kc	Voltage measurements and as reference meter for frequency response check and adjustment	hp Model 400H
Voltmeter Calibrator Generator	Accurate voltage levels from 0.03 to 300 volts rms with drift less than 0.25%, total hum less than 0.25%	Calibration of voltmeter section	hp Model 738A
Oscillator	Frequency range: 5 cps to 600 kc. At least 20 volts open circuit Distortion less than 0.5% below 500 kc	Frequency response and signal-tracing signal	hp Model 200CD
High-Frequency Transformer	Frequency range: 5 to 600 kc	Used in conjunction with 200CD for frequency response measurement on voltmeter higher ranges	hp stock number 200CD-9
Variable Line Transformer	Voltage range: 100 to 130 volts. Monitor meter with an accuracy of 1%.	Vary power-line voltage from 103 to 127 volts	Superior Type UCIM Voltbox

the regulated voltage may cause erroneous or erratic readings. Therefore always check power-supply output voltages and regulation as part of routine maintenance and as a first troubleshooting step. To check the power supply circuit, proceed as follows:

a. With line voltage set at 115 volts and instrument turned on, measure dc voltage at plate of series regulator V8, and compare reading against value shown on schematic diagram. Low voltage indicates defective rectifier tube or defective filter capacitors.

b. Measure the voltage drop across R40; this is an indication of the current delivered by the power supply. If the voltage drop exceeds that shown on the schematic by 20% or more, excessive current is being delivered to some circuit in the instrument.

c. Measure the voltage at pin 8 of V8. The voltage should be +225 volts ±5 volts. With a dc voltmeter connected between pin 8 of V8 and ground, vary the line voltage from 103 to 127 volts and note any variation in the meter reading. The reading on the dc voltmeter should remain within ±2 volts of regulated B+ output voltage.

d. With an ⓗ Model 400H measure the level of the line frequency ripple at pin 8 of V8. If it exceeds 2 millivolts, but regulation is satisfactory, check C17, C18, C19, and C37.

4-13. TROUBLESHOOTING.

4-14. Table 4-4 is supplied as an aid in locating trouble in the distortion analyzer. After the trouble has been localized to a stage or circuit, a tube check and voltage and resistance measurements of this stage or circuit ordinarily should be sufficient to isolate the defective part.

4-15. REPLACEMENT OF PARTS.

4-16. With the exception of the procedures discussed in the following paragraphs, no special techniques are required for repair or replacement of parts. If repairs are extensive or if sensitive adjustments (C12, R62, and R89) are required, the distortion analyzer should be recalibrated (paragraphs 4-38 through 4-48).

Table 4-4. Troubleshooting

Symptoms	Probable Trouble	Correction
Line cord connected to power source, and ac power switch to ON position. Dial lamp does not light.	Defective lamp I1	Replace lamp.
	Blown fuse F1	Replace fuse. Be sure fuse size is correct for 115 or 230 volt operation.
	Power transformer not strapped properly for the line voltage being used	Check strapping of T1 (figures 4-7, 4-8).
FUNCTION switch is set at METER. Test signal of several volts is applied to METER INPUT binding posts. 330B/C/D meter does not show response	Fuse F2 in power supply blown	Replace blown fuse. If fuse blows again, check C17, C18, C37, L8, V7, and V8.
	Defective tube in voltmeter section	Check tubes and replace defective tube. Recalibrate voltmeter (para. 4-38).
	FUNCTION switch defective	Check contacts of the switch.
	Defective component in power supply or voltmeter circuit	Make voltage and resistance checks. Replace defective components.
FUNCTION switch is set at METER. 1000-cps test signal of several volts is applied to METER INPUT binding post. Oscilloscope connected to OUTPUT TO OSCILLOSCOPE binding posts shows test signal but indication is very low	Defective C31	Check C31 and replace if defective.
	Defective CR1 and CR2	Check diodes and replace if defective.
	Defective M1	Check meter. Replace if defective.

Table 4-4. Troubleshooting (Cont'd)

Symptoms	Probable Trouble	Correction
FUNCTION switch is set at NOISE position. INPUT AF-RF switch is set at AF. 1000-cps, 0.08-volt rms test signal is applied to AF INPUT binding posts. INPUT SENSITIVITY control is set maximum clockwise. METER RANGE switch is set at 10 RMS VOLTS. 330B/C/D meter indicates a reading significantly lower than 8 volts or there is no meter indication.	Defective V2, V3, V4, V5, V6	Check tubes and replace defective tube.
	Defective contacts on S2, S4, or S6 if no reading is obtained	Check switch contacts. Replace defective switch if trouble is not corrected by cleaning contacts. Note: S6 must be replaced as an assembly
	Set Level Gain R38 not adjusted properly	Refer to paragraph 4-44g.
	Noise Gain R5 not adjusted properly	Refer to paragraph 4-44j.
	Defective component in selective amplifier circuit	Make voltage and resistance check.
FUNCTION switch is set at DISTORTION. INPUT AF-RF switch is set at AF. Test signal is applied to AF INPUT binding posts. FREQUENCY RANGE switch is set to position which includes fundamental frequency of test signal. COARSE frequency knob is slowly turned across band but there is no dip of meter pointer.	Defective FREQUENCY RANGE switch	Check switch contacts. Replace switch assembly if necessary.
	Defective resistors in FREQUENCY RANGE switch	Replace switch assembly.
		Check R20, R21, R22, R23, R24, R25.
	R89 not adjusted properly	Refer to paragraph 4-46.
		Check C12, C13, and C14.
For Model 330D and Models 330B/C Equipped with AM Detector		
FUNCTION switch is set at SET LEVEL. INPUT AF-RF switch is set at RF. AM carrier with 30% modulation is applied to AF-RF INPUT binding posts. INPUT SENSITIVITY control is maximum clockwise. RF SELECTOR switch is set to position which includes carrier frequency. RF knob is slowly turned across band but meter does not respond.	Defective V1	Check V1 and replace if necessary.
	RF SELECTOR switch defective	Check contacts of the switch.
	Defective rf coils	Check coils and replace if necessary.
	Defective components in AM detector unit	Make voltage and resistance checks. Replace defective components.

4-17. SWITCH REPLACEMENT.

4-18. If a switch requires replacement, mark the wires connected to the wafers with tags to avoid misconnection when the new switch is installed. Follow this procedure whenever the replacement requires disconnecting numerous wires.

4-19. Resistors R26 through R31 in the Wien bridge circuit, are selected and are part of the FREQUENCY RANGE switch assembly (S3). If these parts require replacement, replace the complete FREQUENCY RANGE switch.

4-20. DIODE REPLACEMENT.

4-21. Special high-performance diodes are used for CR1 and CR2. These special diodes are manufactured by Hewlett-Packard Company and are available directly from your Hewlett-Packard Field Office.

4-22. When replacing the diodes, be careful in soldering, because heat may damage them. Place a heat sink on each diode lead as close to the body as possible. This will help conduct heat away from the diode. NOTE: If diodes CR1 and CR2 are replaced, voltmeter calibration and frequency response should be checked (see paragraphs 4-38, 4-40, and 4-42).

4-23. REPLACEMENT OF FREQUENCY DRIVE CABLES.

4-24. The frequency-drive assembly is located directly behind the front panel (see figure 4-5). Two drive cables, one 11 inches and the other 15 inches (length before end loops are formed) are required to replace the drive cables. These two cables are available from Hewlett-Packard Company under ⓗⓟ stock number G-18A.

a. Remove old cable and screws at A, B, C, and D (see figure 4-1). Loosen setscrews in spring-loading collar on rear of drive shaft.

b. Insert free end of 11-inch cable through hole A of drive pulley and form loop in end of cable as shown in figure 4-2. See paragraph 4-26 for procedure.

c. Set instrument tuning dial to high frequency limit and rotate tuning capacitors so plates are open full. Fasten cable at A, and thread as shown in figure 4-1 with other end fastened by screw at B on large drum.

d. Repeat steps b and c using the 15-inch cable; start at C and finish at D on the small drum as shown in figure 4-1.

e. Revolve spring-loading collar counterclockwise (viewed as shown in figure 4-1) until slack is removed from drive cables. Rotate an additional half turn counterclockwise to tighten spring, and then tighten setscrew.

f. Position cable on large drum so that first turn from drive pulley goes around large drum in a plane perpendicular to the axis of the drum and tangent to

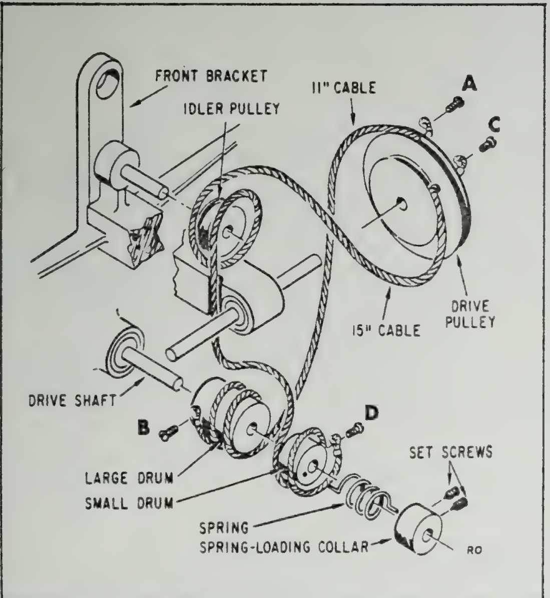


Figure 4-1. Exploded Rear View of Drive Cabling

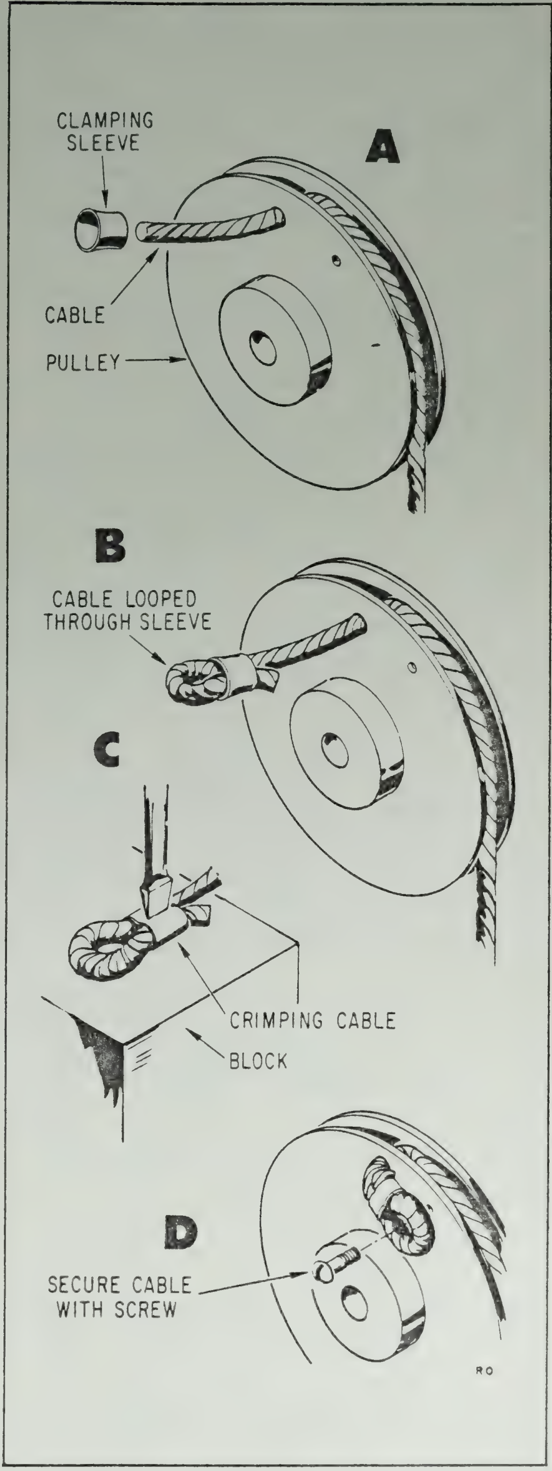


Figure 4-2. Installation of Eyelets on Plastic Coated Cable

the outside of the drive pulley. Cable between idler pulley and small drum should be positioned so that it does not rub in notch in the vertical center post.

g. Rotate tuning dial from one end to the other for approximately 100 complete cycles to work out any stretch and allow cables to position themselves on the drums. Rotors of tuning capacitor sections should not be at the limit of their travel at either end of tuning range.

h. Check dial calibration. If a constant error appears, loosen setscrew in drive pulley (setscrew not shown in figure 4-1) and rotate pulley slightly as required to correct this error.

4-25. INSTALLATION OF CLAMPING EYELETS ON ENDS OF PLASTIC-COATED CABLE.

4-26. Replacement cables are supplied from the factory with a loop formed in one end. The other end is not looped since it is necessary to thread this end through a hole in the drive pulley before the loop is formed (see A of figure 4-2).

a. After passing open end of cable through hole in pulley, form a loop on the end of the cable the same size as the factory-made loop on the opposite end of the cable. Slide eyelet over loop and tap with a plastic headed hammer until eyelet is flat. Size of loop and length of end protruding from eyelet should be the same as the other end of the cable.

b. Crimp center of eyelet as shown in C of figure 4-2 with a screwdriver and a hammer.

c. Cable is now ready to be attached to drive pulley (refer to D of figure 4-2) using the small screw previously removed (step a, paragraph 4-24).

4-27. MECHANICAL ADJUSTMENT OF METER ZERO.

4-28. When meter is properly zero-set, pointer rests over the zero calibration mark on the meter scale when instrument is: 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability:

a. Allow the instrument to operate for at least 20 minutes; this allows meter movement to reach normal operating temperature.

b. Turn instrument off and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.

d. Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If pointer overshoots zero, repeat steps c and d.

e. When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counterclockwise. This is enough to free adjustment screw from the meter suspension. If pointer moves during this step you must repeat steps c through e.

4-29. CALIBRATION AND ADJUSTMENT.

4-30. The following tests should be conducted under the following conditions:

a. Tests should be conducted at normal room temperature.

b. The equipment should warm up for 30 minutes before tests are begun.

c. The line input voltage should be maintained at 115 volts except as otherwise noted. Failure to maintain line voltage at 115 volts may result in poor calibration of the distortion analyzer.

4-31. When making any adjustment always note the original setting and watch the internal voltmeter to observe the electrical effect of the adjustment. By following this practice, the adjustment can be returned easily to its original setting in the event that adjustment of the component does not effect the desired result or that the wrong component was inadvertently adjusted. As a general rule, avoid moving wires and components indiscriminately. Although most wires and components are not sensitive to small shifts in position, repositioning of wires and/or components in some areas may complicate the calibration of the distortion analyzer. Avoid contact with tuning capacitor and frequency range switch parts.

4-32. To calibrate and align the distortion analyzer properly, follow the procedures in the sequence given in paragraphs 4-33 through 4-48.

4-33. REGULATED B+ VOLTAGE.

4-34. The regulated B+ voltage (+225 volts) affects the stability of the distortion analyzer; therefore it is important that this voltage be set correctly before further adjustments are made. To adjust the regulated B+ supply, proceed as follows:

a. Remove cabinet (paragraph 4-4) from distortion analyzer to gain access to B+ Adjust R43 on top of the instrument chassis.

b. Connect instrument to variable line transformer whose output voltage is accurately monitored; set line voltage to 115 volts.

c. Connect dc vacuum tube voltmeter across pin 8 (cathode) of V8 and ground.

d. Adjust R43 to obtain +225 volts.

e. Vary the line voltage from 103 to 127 volts. The voltmeter reading should not vary more than ±2 volts.

4-35. ZERO SETTING METER M1.

4-36. See paragraph 4-28.

4-37. VOLTMETER CALIBRATION.

4-38. Calibrate the voltmeter section as follows:

a. Set controls of distortion analyzer:

(1) FUNCTION switch to METER.

(2) METER RANGE switch to 1.0 RMS VOLTS.

b. Connect the output of voltmeter calibrator to METER INPUT binding posts; adjust calibrator output to 1.0 volt rms.

c. Adjust VM Gain control R62 (figure 4-5) to set meter pointer exactly on 1.0 RMS VOLTS on 0-1 scale.

d. Check voltmeter full-scale calibration on all ranges by adjusting the output of the voltmeter calibrator from 0.03 to 300 volts rms. Voltmeter error should be no greater than ±3% of full scale. On the 100-volt range, adjust the value of R77 (typical value is from 82,000 to 150,000 ohms) to obtain the proper reading. On the 300-volt range, adjust the value of R78 (typical value is from 120,000 to 180,000 ohms) by padding to obtain the proper reading.

e. Check meter scale tracking at 0.1 volt increments. If variation is more than ±2%, replace CR1 and CR2 and recalibrate the voltmeter (steps a through d).

f. Adjust calibrator output to 0.9 volt rms.

g. Vary the line voltage from 103 to 127 and note any deviation in the voltmeter reading. If the variation is more than ±3% of full scale (0.87 to 0.93 on 0-1 scale) replace tubes V11, V12, and/or V13 and repeat steps a through g.

h. Disconnect calibrator from METER INPUT binding posts.

i. Connect a 10-megohm resistor across AF INPUT binding posts; cover AF INPUT binding posts with a grounded metal shield, such as a General Radio 274-NK.

j. Set controls of distortion analyzer:

(1) INPUT AF-RF switch to AF.

(2) INPUT SENSITIVITY control full clockwise.

(3) FREQUENCY RANGE switch and FREQUENCY dial to power-line frequency.

(4) FUNCTION switch to DISTORTION.

(5) METER RANGE switch to .03 RMS VOLTS.

k. Adjust Hum Bal adjustment R41 for a minimum indication on the internal voltmeter. It should be less than 0.3 millivolts.

m. Set FUNCTION switch to METER.

n. Remove grounded metal shield and 10-megohm resistor from AF INPUT binding posts and place them across the METER INPUT binding posts.

p. Record the meter reading. It should be less than 1 millivolt. If proper reading is not obtained replace tubes V11, V12, and/or V13 and repeat steps a through p.

4-39. 330B VOLTMETER SECTION, FREQUENCY RESPONSE.

4-40. For frequency response adjustment proceed as follows (for Models 330C and 330D refer to paragraph 4-41):

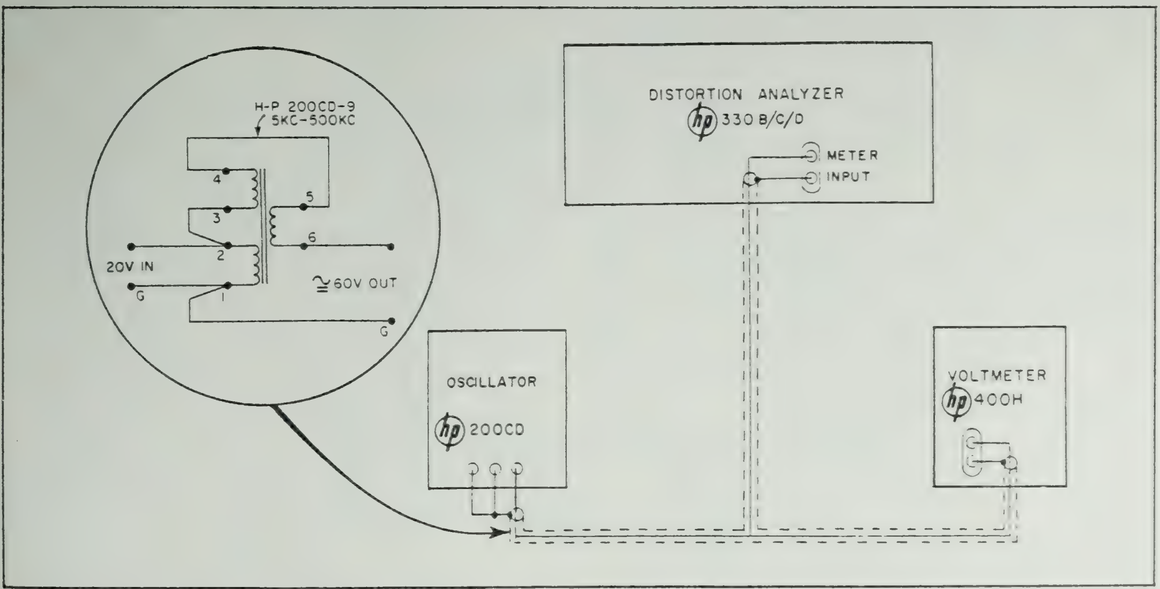


Figure 4-3. Test Bench Equipment Arrangement

a. Connect equipment as shown in figure 4-3. Set 330B voltmeter and 400H to 30-volt range. Adjust output frequency of 200CD to 5000 cps and adjust its output to produce reading of 0.9 on 0-1 scale of 330B meter. Record reading obtained on 400H (this meter reading is referred to as "reference level" in the following procedure).

b. Set FUNCTION switch to METER.

c. Change output frequency of 200CD to 100,000 cps and adjust its output amplitude to the reference level.

d. Note the reading on 330B meter. The meter should indicate between 0.87 and 0.93 on 0-1 scale. If proper reading is not obtained replace tubes V11, V12, and/or V13.

e. Disconnect transformer 200CD-9. Connect equipment as shown in figure 4-4. Set 330B voltmeter and 400H to .03-volt range. Adjust output frequency of 200CD to 1000 cps and adjust its output amplitude to obtain reading of 0.9 on 0-1 scale of 330B meter. Record reading obtained on 400H (reference level).

f. Repeat steps c and d. If proper reading is not obtained, check for possible ground loop (figure 2-3) formed by equipment connection.

g. Set 330B voltmeter and 400H to 0.1-volt range. Adjust output frequency of 200CD to 1000 cps and adjust its output amplitude to produce reading of 0.9 on 0-1 scale of 330B meter. Record reading obtained on 400H (reference level).

h. Repeat steps c and d. If proper reading is not obtained, adjust C25 (figure 4-6) at 100,000 cps to bring the high frequency reading to within ±0.3 of 0.9 on 0-1 scale.

i. Change the output frequency of 200CD to 10 cps and adjust its output amplitude to the reference level. The 330B voltmeter reading should be within ±0.3 of 0.9 on 0-1 scale.

j. Remove shunt resistor from the 200CD output.

k. Connect transformer 200CD-9 as shown in figure 4-3 and check frequency response on 100- and 300-volt ranges. Establish a 5000-cps reference level on each range and check response from 5000 cps to 100,000 cps. Adjust C20 (figure 4-6) at 100,000 cps on 100RMS VOLTS range to bring the high-frequency reading within ±0.3 of reference reading. Adjust C23 (figure 4-6) at 100,000 cps on 300 RMS VOLTS range to bring the high-frequency reading to within ±0.3 of reference reading.

4-41. 330C/D VOLTMETER SECTION, FREQUENCY RESPONSE.

4-42. Procedure:

a. Connect equipment as shown in figure 4-4. Set 330C/D meter and 400H to .03-volt range. Adjust output frequency of 200CD to 1000 cps and adjust its output amplitude to produce a reading of 0.9 on 0-1 scale of 330C/D meter. Record reading obtained on 400H (this meter reading is referred to as "reference level" in the following procedure).

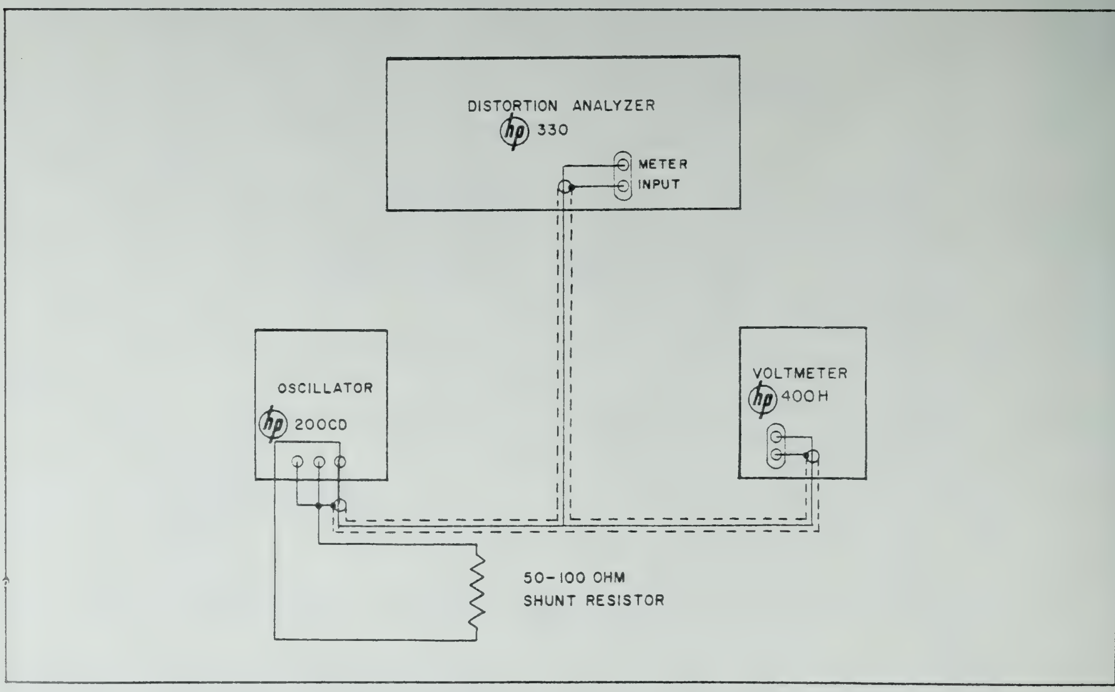


Figure 4-4. Test Bench Equipment Arrangement with Shunt Resistor

b. Change output frequency of 200CD to 20,000 cps and adjust its output amplitude to the reference level. The 330C/D meter should indicate between 0.87 and 0.93 on 0-1 scale.

c. Change output frequency of 200CD to 60,000 cps and adjust its output amplitude to the reference level. The 330C/D meter should indicate between 0.84 and 0.96 on 0-1 scale. If proper reading is not obtained, check for possible ground loop (figure 2-3) caused by equipment connection.

d. Change output frequency of 200CD to 10 cps and adjust its output amplitude to the reference level. The 330C/D voltmeter reading should be within ±0.3 of 0.9 on 0-1 scale.

e. Check frequency response on 0.1-volt range using the same procedure as described in steps a through d above.

f. Remove shunt resistor from 200CD output.

g. Change the output frequency of 200CD to 500,000 cps and adjust its output amplitude to +20 db on the Model 400H.

h. Frequencies of 500 kc and above should be attenuated at least 40 db, thus the reading on the 330C/D voltmeter should be less than -20 db. If proper reading is not obtained, check C35, C36, and C38.

i. Connect transformer 200CD-9 as shown in figure 4-3. Set 330C/D voltmeter and 400H to 30-volt range. Adjust output frequency of 200CD to 5000 cps and adjust its output amplitude to obtain reading of 0.9 on 0-1 scale of 330C/D meter. Record reading obtained on 400H (reference level).

j. Repeat steps b and c above, and adjust C33 to obtain within ±0.3 of 0.9 on 0-1 scale at 20 kc and ±0.6 of 0.9 at 60 kc.

k. Establish 5000-cps reference level on 100- and 300-volt ranges and check response from 5000 cps to 60,000 cps. Adjust C20 (figure 4-6) at 60,000 cps on 100 RMS VOLTS range to obtain ±0.3 of reference reading at 20,000 cps and ±0.6 of reference reading at 60,000 cps. Adjust C23 (figure 4-6) at 60,000 cps on 300 RMS VOLTS range to obtain within ±0.3 of reference reading at 20,000 cps and ±0.6 of reference reading at 60,000 cps.

4-43. INTERNAL AMPLIFIER ADJUSTMENTS.

4-44. GAIN ADJUSTMENTS.

a. Remove V6 from its socket.

b. Set controls of distortion analyzer as follows:

(1) INPUT AF-RF switch to AF.

(2) FREQUENCY RANGE switch to X10.

(3) INPUT SENSITIVITY control full clockwise.

(4) FREQUENCY dial on "20".

(5) FUNCTION switch to SET LEVEL.

(6) METER RANGE switch to 300 RMS VOLTS.

c. Adjust output frequency of 200CD to 1000 cps and connect it to the AF INPUT binding posts. Connect 400H across the AF INPUT binding posts and adjust 200CD output amplitude to 0 db on the 400H.

d. With 400H measure the signal level between pin 8 (cathode) of V4 and ground. The 400H should indicate between +18 and +19 db. If the proper reading is not obtained, replace tubes V2, V3, and/or V4. If necessary, pad R13 with a resistor (typical value is from 82,000 to 150,000 ohms in parallel with 22,000 ohms).

e. Reinsert V6 in its socket.

f. Set METER RANGE switch to +20 DB.

g. Adjust Set Level Gain adjustment R38 to set meter pointer exactly on 0 DECIBELS.

h. Change 200CD output level to exactly -20 db.

i. Set FUNCTION switch to NOISE.

j. Adjust Noise Gain adjustment R5 to set meter pointer exactly on 0 DECIBELS.

4-45. HUM ADJUSTMENT.

a. Disconnect 200CD output from AF INPUT binding posts. Connect a 10-megohm resistor across AF INPUT binding posts and cover AF INPUT binding posts with a grounded metal shield, such as a GR 274-NK.

b. Set controls of distortion analyzer as follows:

(1) FREQUENCY RANGE switch and FREQUENCY dial to power-line frequency.

(2) FUNCTION switch to DISTORTION.

(3) METER RANGE switch to .03 RMS VOLTS.

c. Adjust HUM BAL adjustment R41 for minimum indication on the internal voltmeter; should be less than 3 millivolts (3 minor meter divisions on 0-3 scale).

d. Check level of residual noise:

(1) Set FUNCTION switch to SET LEVEL and read residual on internal meter; should be less than 1.0 millivolt.

(2) Set FUNCTION switch to NOISE and note the meter indication. It should be less than 7 millivolts (7 minor meter divisions on 0-3 scale). If proper readings are not obtained, replace tubes V2, V3, V4, V5, and/or V6.

4-46. ADJUSTING WIEN BRIDGE.

a. Set controls of distortion analyzer as follows:

(1) INPUT AF-RF switch to AF.

(2) FREQUENCY RANGE switch to X10.

(3) FREQUENCY dial on "20".

(4) FUNCTION switch to DISTORTION.

(5) METER RANGE switch to +20 DB.

(6) BALANCE control to its mid-range position.

b. Adjust output frequency of 200CD to 200 cps and adjust its output level to 0 db. Connect 200CD output to the AF INPUT binding posts.

c. Adjust FREQUENCY FINE and BALANCE controls for minimum voltmeter reading. Set frequency to low end of dial (20) on the X10 range.

d. Set METER RANGE switch to 0 DB.

e. Rotate BALANCE control fully counterclockwise and note the internal voltmeter reading.

f. Rotate BALANCE control full clockwise and note the internal voltmeter reading. Compare the two readings. Adjust R89 (Figure 4-5) and FINE FREQUENCY control until BALANCE control can be rotated fully clockwise and fully counterclockwise with less than ±1 db difference between the two readings.

g. Set FREQUENCY dial to "200."

h. Adjust output frequency of 200CD to 2000 cps and adjust its output level to 0 db. Repeat steps c through e and adjust C12 (Figure 4-5) and FINE FREQUENCY control until BALANCE control can be rotated fully clockwise and fully counterclockwise with less than ±1 db between the two readings.

NOTE

R89 and C12 interact, therefore repeat the adjustment several times.

i. The BALANCE control between its extremities should not exceed 10 db between 20 cps to 20 Kc.

4-47. FREQUENCY DIAL CALIBRATION.

4-48. When the tuning capacitor drive assembly has been disassembled, or if the screws that retain the dial shaft have been loosened through vibration, the FREQUENCY tuning dial may shift out of position. To return the dial to its proper position, proceed as follows:

a. Set controls of distortion analyzer:

(1) BALANCE control to its mid-range position.

(2) FREQUENCY RANGE switch to X10.

(3) INPUT AF-RF selector switch to AF.

(4) FUNCTION switch to DISTORTION.

(5) METER RANGE switch to +20 DB.

b. Adjust output frequency of 200CD to exactly 2 kc. Check output frequency with an electronic counter or with a frequency standard and an oscilloscope (using Lissajous pattern).

c. Connect 1-volt rms, 2-kc signal to AF INPUT binding posts.

d. Adjust FREQUENCY tuning control knobs (COARSE and FINE) for minimum indication on the internal voltmeter. Decrease setting of METER RANGE switch to maintain up-scale indication on meter.

e. Readjust tuning controls until no further reduction in meter reading can be obtained.

f. Hold tuning capacitor drive shaft securely in this position with a pair of pliers, gripping the drive shaft collar on the inside end of the shaft. Remove the COARSE tuning control knob by loosening the two setscrews. Slip the FREQUENCY tuning dial around its hub until the "200" mark lines up exactly with the line down the center of the FREQUENCY tuning dial window. Tighten allen screws in the collar of the frequency dial shaft by inserting an allen head wrench through the shaft hole in the front of the front panel.

g. Change output frequency of 200CD to 200 cps and repeat steps d and e. The dial calibration should be within ±2%.

h. Check frequency dial calibration at 250 cps, 300 cps, 350 cps, 500 cps, 800 cps, and 1 kc. If the calibration error is greater than ±2%, attempt correction by selection of V5. Excessive grid current in this tube can cause an unbalanced condition in the bridge circuit. If the calibration error varies more than ±2% across the band, compromise setting of frequency dial and capacitor C12 may be necessary.

i. Check frequency dial calibration on X1 and X100 positions of the FREQUENCY RANGE switch. If the calibration error is greater than ±2% on one range only, check the resistors in the frequency-determining network for that particular range.

4-49. FINAL TESTS.

4-50. The following tests are made with the instrument in its case and will verify that the repaired instrument is operating normally and is accurately calibrated.

4-51. VOLTMETER CALIBRATION.

a. Connect distortion analyzer to variable power source, set line voltage to rated value (115/230 volts), and turn distortion analyzer on allowing at least a 5-minute warmup.

b. Set FUNCTION switch to METER; set METER RANGE to 1.0 RMS VOLTS.

c. Connect output of voltmeter calibrator to METER INPUT binding posts.

d. Check 330 voltmeter reading versus voltmeter calibrator output on each of METER RANGE positions. Maximum 330 voltmeter error should be no greater than ±3% of full scale.

e. Repeat step d (on one range only) at line voltage of 103 and 127 volts.

f. Check meter tracking of 330 voltmeter at 0.1 volt increments. Variation should be less than ±3% of full scale.

4-52. VOLTMETER FREQUENCY RESPONSE.

a. Connect equipment as shown in figure 4-3.

b. Check frequency response from 10 cps to 100,000 cps for Model 330B and from 10 cps to 60,000 cps for Models 330C and 330D on all ranges. Establish a reference reading on the 330 voltmeter at either 1000 cps

or 5000 cps (when using transformer 200CD-9) on each of the 330 voltmeter ranges; note the 400H reading. Then change the 200CD output frequency as specified below, adjusting the 200CD output level to obtain the noted 400H reading. Compare the new 330 voltmeter reading with the reference reading; permissible limits are given below.

For Model 330B	10 cps to 100,000 cps ±3%
For Model 330C	10 cps to 20,000 cps ±3%
For Model 330D	10 cps to 60,000 cps ±6%

c. Repeat step b (on one range only) at line voltage of 103 and 127 volts.

4-53. INTERNAL AMPLIFIER.

a. Adjust output frequency of 200CD to 1000 cps and adjust its output level to exactly -20 db. Connect 200CD output to AF INPUT binding posts.

b. Set FUNCTION switch to SET LEVEL; METER RANGE switch to 0 DB and INPUT SENSITIVITY control maximum clockwise. The 330 meter should indicate 0 DB.

c. Turn FUNCTION switch to NOISE and METER RANGE switch to +20 DB. The 330 meter should indicate +20 DB.

d. Turn FUNCTION switch to DISTORTION; set FREQUENCY RANGE switch to X10 and FREQUENCY dial to "100". Adjust BALANCE and FREQUENCY FINE control for minimum 330 meter reading. The distortion reading should be less than 1/2%. Check FREQUENCY dial calibration; dial should indicate the frequency within ±2%.

e. Adjust output frequency of 200CD to 10,000 cps, adjust its output level to exactly -20 db, and repeat step d (FREQUENCY RANGE switch set at X100). Check FREQUENCY dial calibration; dial should indicate the frequency within ±2%.

4-54. RESIDUAL READINGS.

a. Connect a 10-megohm resistor across METER INPUT binding posts; cover METER INPUT binding posts with a grounded metal shield such as a GR274-NK.

b. Set FUNCTION switch to METER and METER RANGE switch to .03 RMS VOLTS.

c. Note meter reading; should be less than 1 millivolt.

d. Remove metal shield and 10-megohm resistor from METER INPUT binding posts and place them across AF INPUT binding posts.

e. Set FUNCTION switch to DISTORTION, AF-RF INPUT switch to AF, INPUT SENSITIVITY control full clockwise, and adjust FREQUENCY controls to power-line frequency.

f. Read the residual; should be less than 3.0 millivolt.

g. Set FUNCTION switch to SET LEVEL and read residual; should be less than 1.0 millivolt.

h. Set FUNCTION switch to NOISE and read the residual; should be less than 70 microvolts.

4-55. CHECK OF SECOND HARMONIC ATTENUATION.

a. Connect 200CD and 400H to AF INPUT binding posts.

b. Turn FUNCTION switch to SET LEVEL.

c. Adjust output frequency of 200CD to 200 cps, adjust its output level to 0.3 volt rms, and set distortion analyzer FREQUENCY controls for 100 cps.

d. Adjust INPUT SENSITIVITY control so that the meter pointer is at 0 DECIBELS when the METER RANGE switch is set at +10 DB.

e. Turn FUNCTION switch to DISTORTION; keep the 200CD output level constant.

f. The meter reading should not drop more than 1.5 db.

g. Repeat the test above with the distortion analyzer set for frequencies of 1.5, 5, and 20 kc, and the 200CD set for frequencies of 3, 10, and 40 kc. In 5- and 20-kc tests, the meter reading should not drop more than 3 db.

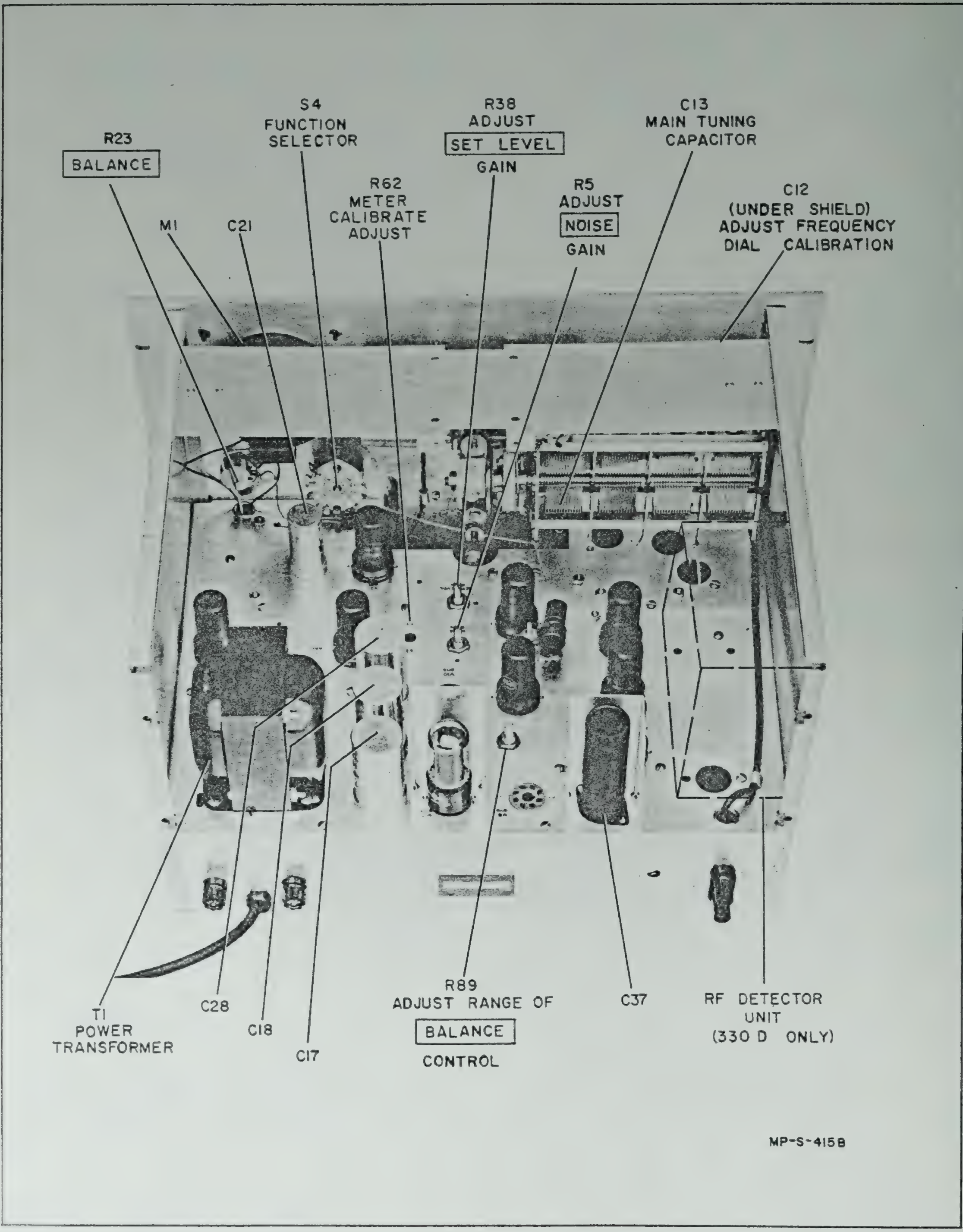


Figure 4-5. Top View of Chassis

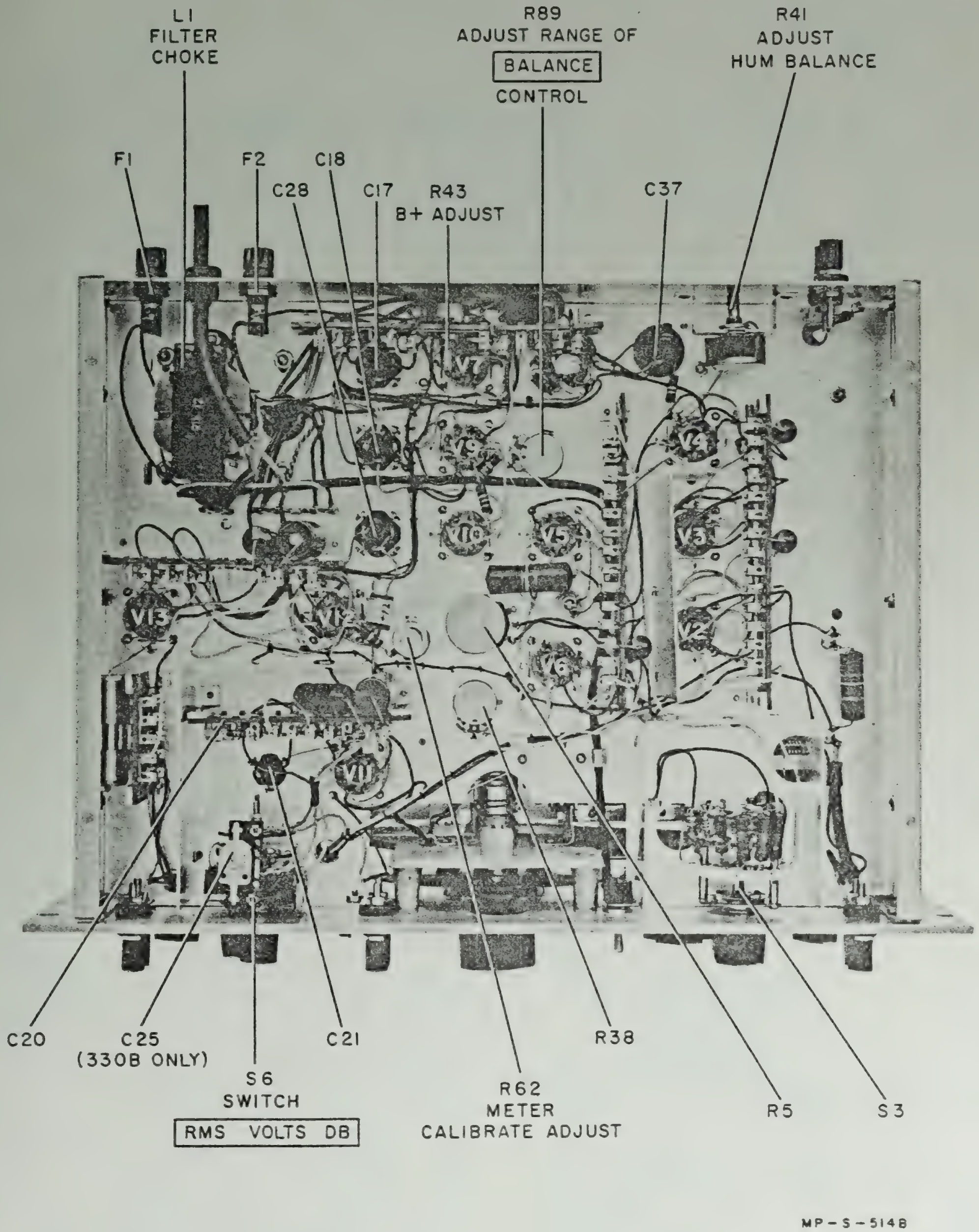


Figure 4-6. Bottom View of Chassis

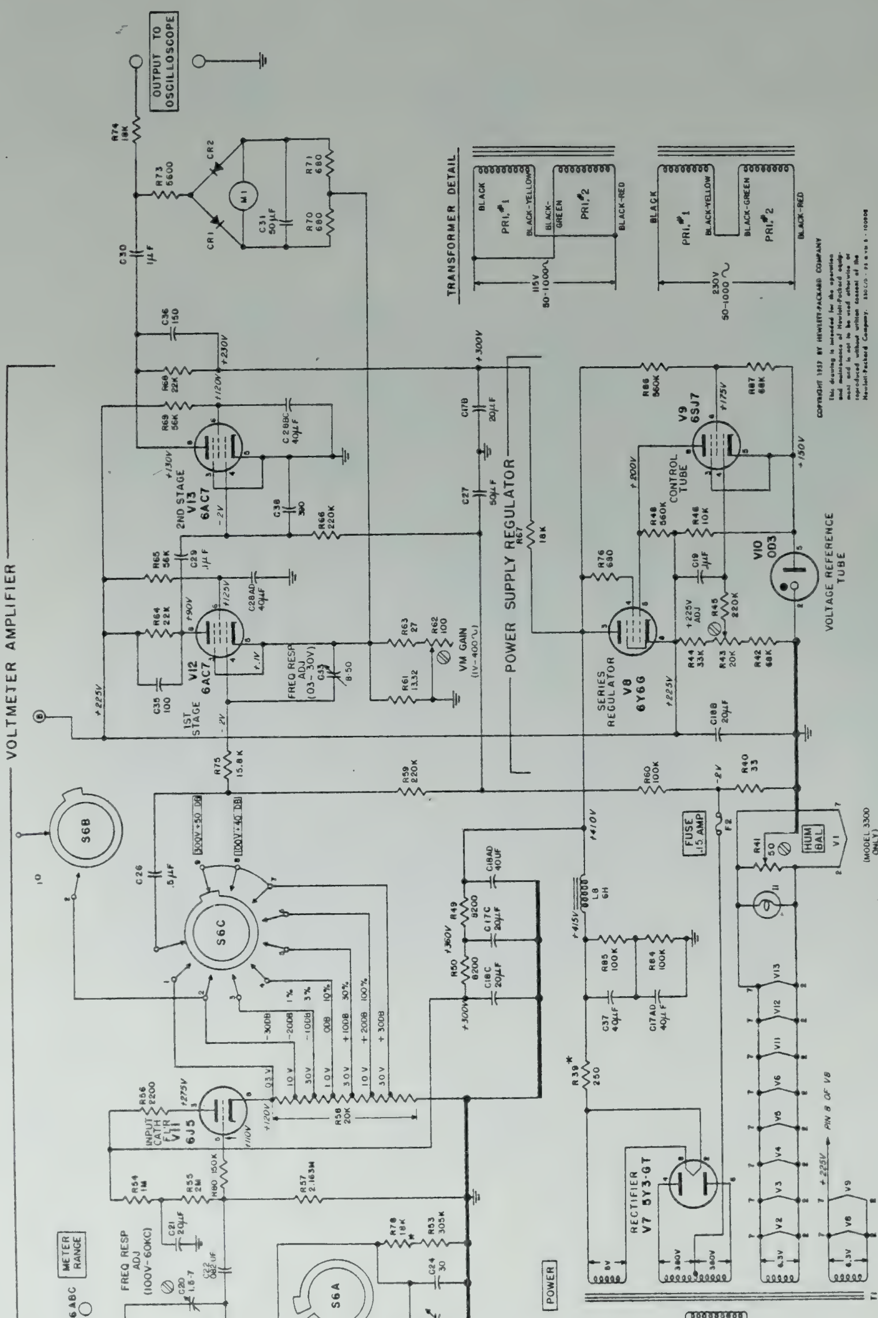


Figure 4-7. Model 330C/D Power Supply and Voltmeter Section

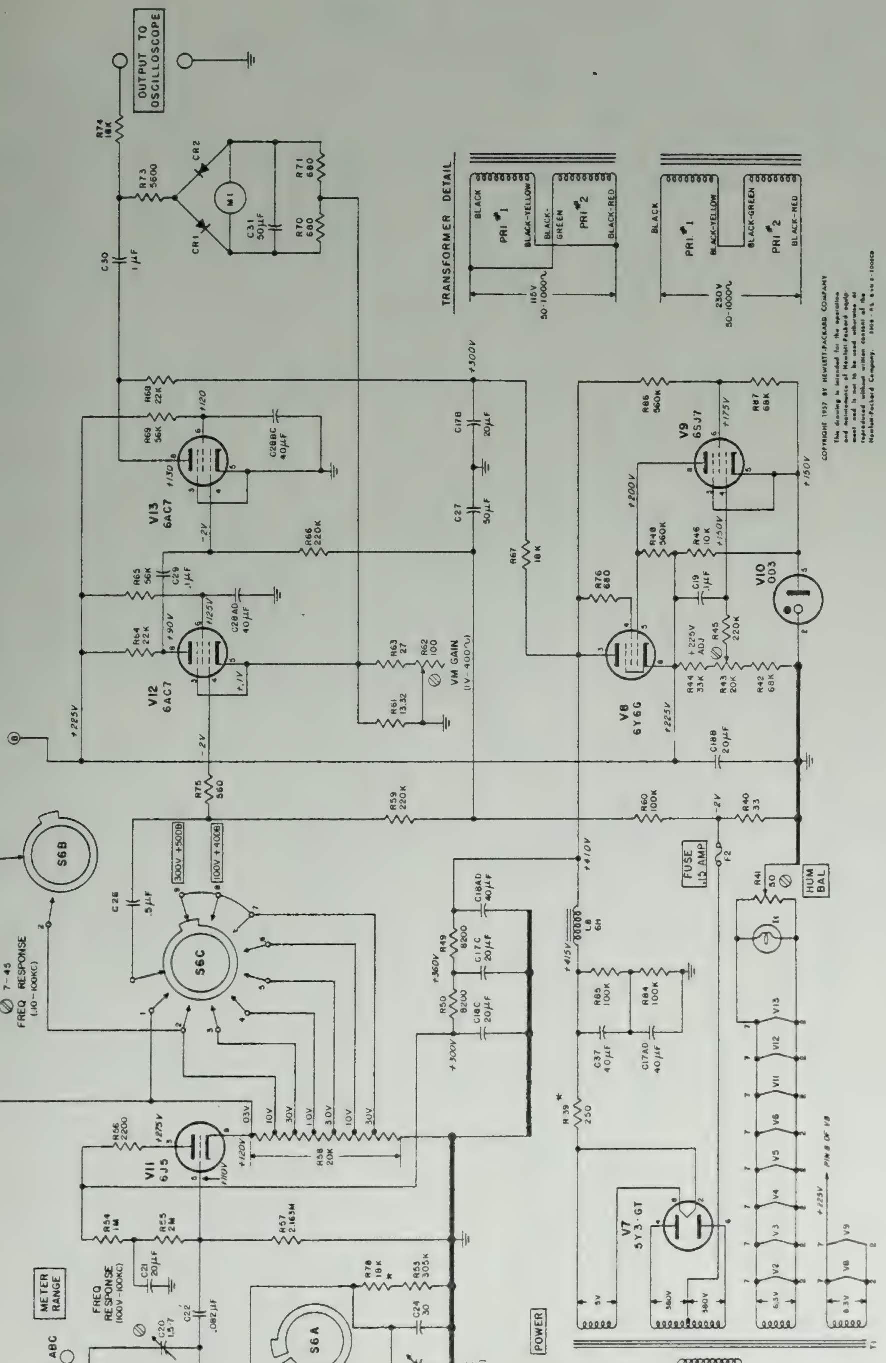


Figure 4-8. Model 330B Power Supply and Voltmeter Section

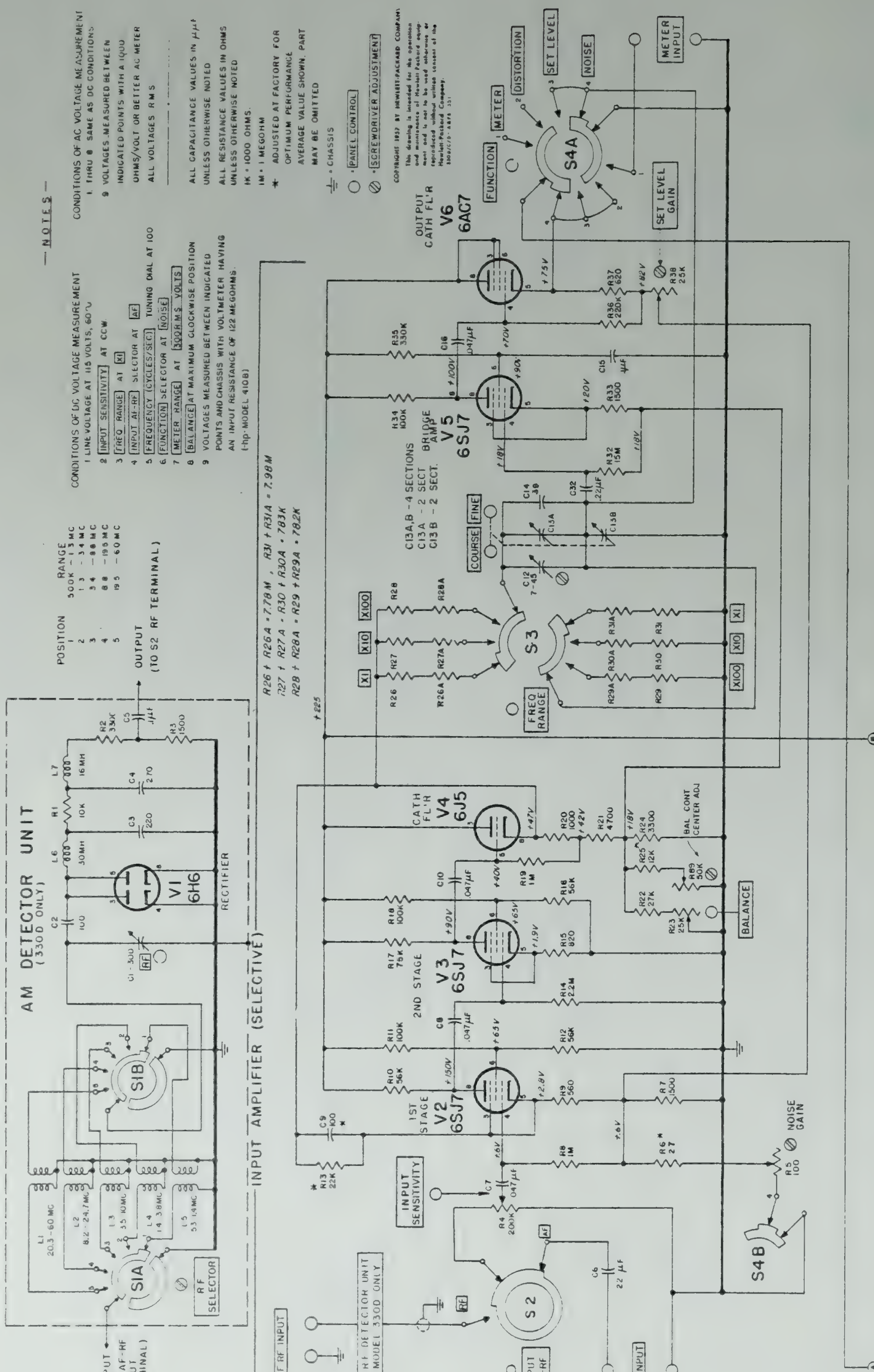


Figure 4-9. Model 330B/C/D Amplifier and Filter Section

SECTION V
REPLACEABLE PARTS

5-1. INTRODUCTION.

5-2. This section contains information for ordering replacement parts for the Model 330B/C/D Distortion Analyzer.

5-3. Table 5-1 lists replaceable parts in alphanumerical order of their reference designators. Detailed information on a part used more than once in the instrument is listed opposite the first reference designator applying to the part. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

a. Reference designator.

b. Full description of the part.

c. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

d. Hewlett-Packard stock number.

e. Total quantity used in the instrument (TQ col).

f. Recommended spare quantity for complete maintenance during one year of isolated service (RS col).

5-4. ORDERING INFORMATION.

5-5. To order a replacement part, address order or inquiry to your authorized Hewlett-Packard Field Office. (See maps at rear at rear of this manual for addresses.)

5-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

5-7. To order a part not listed in table 5-1, give a complete description of the part and include its function and location.

Table 5-1. Replaceable Parts

Ckt Ref.	Description	Mfr	hp Stock No.	TQ			
C1	Model 330B/C, not assigned						
	Model 330D Capacitor: variable, air, 12 pf to 300 pf	71218	0121-0005	1			
C2	Model 330B/C, not assigned						
	Model 330D Capacitor: fixed, mica, 100 pf ±10%, 500 vdcw	76433	0140-0054	2			
C3	Model 330B/C, not assigned						
	Model 330D Capacitor: fixed, mica, 220 pf ±10%, 500 vdcw	76433	0140-0031	1			
C4	Model 330B/C, not assigned						
	Model 330D Capacitor: fixed, mica, 270 pf ±10%, 500 vdcw	00853	0140-0015	1			
C5	Model 330B/C						

Table 5-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*			
C5	Model 330B/C, not assigned						
	Model 330D Capacitor: fixed, paper, 0.1 μf ± 10%, 600 vdcw	56289	0160-0001	1			
C6	Capacitor: fixed, paper, .22 μf ± 10%, 400 vdcw	56289	0160-0018	2			
C7, 8	Capacitor: fixed, paper, .047 μf ± 10%, 600 vdcw	56289	0160-0005	4			
C9	Capacitor: fixed, mica, 100 pf ± 10%, 500 vdcw Optimum value selected at factory Average value shown	76433	0140-0054	1			
C10	Same as C7						
C11	Not assigned						
C12	Capacitor: variable, ceramic 7-45 pf 500 vdcw	72982	0130-0001	4			
C13	Capacitor: variable, air, 4 sections, 12.4-535 pf/sect.	76854	0121-0002	1			
C14	Capacitor: fixed, ceramic 39 pf ± 5%, 500 vdcw	96095	0150-0002	1			
C15	Capacitor: fixed, paper, 0.1 μf ± 10%, 600 vdcw	56289	0160-0001	3			
C16	Same as C7						
C17, 18	Capacitor: fixed, electrolytic, 4 sections, 20 μf/sect.	56289	0180-0025	3			
C19	Same as C15						
C20	Capacitor: variable, ceramic, 1.5-7 pf 500 vdcw	72982	0130-0011	1			
C21	Capacitor: fixed, electrolytic, 20 μf, 450 vdcw	56289	0180-0011	1			
C22	Capacitor: fixed, paper, .082 μf ± 10%, 600 vdcw	56289	0160-0032	1			
C23	Capacitor: variable, ceramic, 8-50 pf	72982	0130-0008	1			
C24	Capacitor: fixed, mica, 30 pf ± 5%, 500 vdcw	00853	0140-0105	1			
C25	Model 330B Same as C12						
	Model 330C/D, not assigned						

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	ⓗⓟ Stock No.	TQ*			
C26	Capacitor: fixed, paper, 0.5 μf ± 10%, 400 vdcw	14655	0160-0024	1			
C27	Capacitor: fixed, electrolytic, 50 μf -10% + 200%, 50 vdcw	00656	0180-0029	2			
C28	Same as C17						
C29	Same as C15						
C30	Capacitor: fixed, paper, 1 μf ± 20%, 400 vdcw	56289	0160-0016	1			
C31	Same as C27						
C32	Same as C6						
C33	Model 330B, not assigned						
	Model 330C/D Capacitor: variable, ceramic, 8-50 pf, 500 VDC	72982	0130-0017	1			
C34	Model 330B, not assigned						
	Model 330C/D, not assigned						
C35	Model 330C/D Same as C2						
C36	Model 330C/D						
	Capacitor: fixed, mica, 150 pf ± 10%, 500 vdcw	76433	0140-0055	1			
C37	Capacitor: fixed, electrolytic, 40 μf, 450 vdcw	56289	0180-0024	1			
C38	Model 330B, not assigned						
	Model 330C/D Capacitor: fixed, mica, 390 pf ± 10%, 500 vdcw	76433	0140-0030	1			
CR1,2	Diode, silicon	07263	1901-0040	2			
F1	Fuse, cartridge: 1.6 amp, (115V operation)	71400	2110-0005	1			
	Fuse, cartridge: 0.8 amp, (230V operation)	75915	2110-0020				
F2	Fuse, cartridge: .15 amp, slo-blo	71400	2110-0017	1			
I1	Lamp, incandescent: 6-8V, 2 pin base, GE #12	24455	2140-0012	1			
L1	Model 330B/C, not assigned						

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	® Stock No.	TQ*			
	Model 330D Coil, rf range 5: 20 mc - 60 mc	28480	33B-60E	1			
L2	Model 330B/C, not assigned						
	Model 330D Coil, rf range 4, 8.5 mc - 24 mc	28480	33B-60D	1			
L3	Model 330B/C, not assigned						
	Model 330D Coil, rf range 3, 3.5 mc - 10 mc	28480	33B-60C	1			
L4	Model 330B/C, not assigned						
	Model 380D Coil, rf range 2, 1.4 mc - 3.8 mc	28480	33B-60B	1			
L5	Model 330B/C, not assigned						
	Model 330D Coil, rf range 1, 530 kc - 1.4 mc	28480	33B-60A	1			
L6	Model 330B/C, not assigned						
	Model 330D Coil, rf, 30 mh, 150 ohms	98405	9140-0003	1			
L7	Model 330B/C, not assigned						
	Model 330D Coil, rf, 16 mh, 100 ohms	98405	9140-0004	1			
L8	Reactor: 6h @ 125 ma, 240 ohms	28480	9110-0004	1			
M1	Model 330B, Meter	28480	1120-0005	1			
	Model 330C/D, Meter	28480	1120-0008	1			
P1	Model 330B/C, not assigned						
	Model 330D Connector, female: coaxial	71785	1251-0016	1			
P2	Power cord	70903	8120-0015	1			
R1	Model 330B/C, not assigned						
	Model 330D Resistor: fixed, composition, 10,000 ohms ± 10%, 2 W	01121	0693-1031	1			
R2	Model 330B/C, not assigned						
	Model 330D Resistor: fixed, composition, 3300 ohms ± 10%, 1 W	01121	0690-3321	1			
R3	Model 330B/C, not assigned						

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	Stock No.	TQ*			
	Model 330D Resistor: fixed, composition, 1500 ohms ±10%, 1 W	01121	0690-1521	3			
R4	Resistor: variable, composition, log taper, 200,000 ohms ±10%, 2 W	01121	2100-0180	1			
R5	Resistor: variable, wirewound, 100 ohms ±10%, 2 W	71450	2100-0003	1			
R6	Model 330B Resistor: fixed, composition, 27 ohms ±10%, 1 W Optimum value selected at factory Average value shown	01121	0690-2701	2			
	Model 330C/D Resistor: fixed, composition, 47 ohms ±10%, 1 W	01121	0690-4701	1			
R7	Same as R3						
R8	Resistor: fixed, composition, 1 megohm ±10%, 1 W	01121	0690-1051	3			
R9	Resistor: fixed, composition, 560 ohms ±10%, 1 W	01121	0690-5611	2			
R10	Resistor: fixed, composition, 56,000 ohms ±10%, 1 W	01121	0690-5631	5			
R11	Resistor: fixed, composition, 100,000 ohms ±10%, 1 W	01121	0690-1041	6			
R12	Same as R10						
R13	Resistor: fixed, composition, 22,000 ohms ±10%, 1 W Optimum value selected at factory Average value shown	01121	0690-2231	1			
R14	Resistor: fixed, composition, 2.2 megohms ±10%, 1 W	01121	0690-2251	1			
R15	Resistor: fixed, composition, 820 ohms ±10%, 1 W	01121	0690-8211	1			
R16	Same as R10						
R17	Resistor: fixed, composition, 75,000 ohms ±5%, 1 W	01121	0689-7535	1			
R18	Same as R11						
R19	Same as R8						
R20	Resistor: fixed, composition, 1000 ohms ±10%, 1 W	01121	0690-1021	1			

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	® Stock No.	TQ*			
R21	Resistor: fixed, composition, 4700 ohms ± 10%, 2 W	01121	0693-4721	1			
R22	Resistor: fixed, composition, 27,000 ohms ±10%, 1 W	01121	0690-2731	1			
R23	Resistor: variable, composition, 25,000 ohms ±20%, 1/3 W	71450	2100-0009	3			
R24	Resistor: fixed, composition, 3300 ohms ± 10%, 1 W	01121	0690-3321	1			
R25	Resistor: fixed, composition, 12,000 ohms ± 10%, 1 W	01121	0690-1231	1			
R26 thru R31	Part of Range Switch Assembly (not separately replaceable)						
R32	Resistor: fixed, composition, 15 megohms ± 10%, 1/2 W	01121	0687-1561	1			
R33	Same as R3						
R34	Same as R11						
R35	Resistor: fixed, composition, 330,000 ohms ± 10%, 2 W	01121	0693-3341	1			
R36	Resistor: fixed, composition, 220,000 ohms ± 10%, 1 W	01121	0690-2241	1			
R37	Resistor: fixed, composition, 620 ohms ± 5%, 1 W	01121	0689-6215	1			
R38	Same as R23						
R39	Resistor: fixed, wirewound, 250 ohms ± 10%, 10 W Optimum value selected at factory Average value shown	12697	0816-0001	1			
R40	Resistor: fixed, composition, 33 ohms ± 10%, 1 W	01121	0690-3301	1			
R41	Resistor: variable, wirewound, 50 ohms ± 10%, 2 W	71450	2100-0002	1			
R42	Resistor: fixed, composition, 68,000 ohms ± 10%, 1 W	01121	0690-6831	1			
R43	Resistor: variable, composition, linear taper, 20K ohms ±20%, 1/4W	11237	2100-0093	1			
R44	Resistor: fixed, composition, 33,000 ohms ± 10%, 1 W	01121	0690-3331	1			
R45	Resistor: fixed, composition, 220,000 ohms ± 10%, 1/2 W	01121	0687-2241	3			

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	Stock No.	TQ*			
R46	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W	01121	0693-1031	1			
R47	Not assigned						
R48	Resistor: fixed, composition, 560,000 ohms ± 10%, 1 W	01121	0690-5641	2			
R49, 50	Resistor: fixed, composition, 8200 ohms ± 10%, 1 W	01121	0690-8221	2			
R51	Not assigned						
R52	Resistor: fixed, deposited carbon, 2.163 megohms ± 1%, 1 W	19701	0730-0113	2			
R53	Resistor: fixed, deposited carbon, 305,000 ohms ± 1%, 1 W	19701	0730-0084	1			
R54	Same as R8						
R55	Resistor: fixed, deposited carbon, 2 megohms ± 1%, 1 W	19701	0730-0112	1			
R56	Resistor: fixed, composition, 2200 ohms ± 10%, 1 W	01121	0690-2221	1			
R57	Same as R52						
R58	Resistor Set includes:	28480	33B-26D	1			
	R58A, 13,560 ohms	28480	33B-26G				
	R58B, 4459.0 ohms	28480	33B-26F				
	R58C, 1364.7 ohms	28480	33B-26J				
	R58D, 432.40 ohms	28480	33B-26K				
	R58E, 136.66 ohms	28480	33B-26L				
	R58F, 43.230 ohms	28480	33B-26M				
	R58G, 19.982 ohms	28480	33B-26N				
R59	Same as R45						
R60	Same as R11						
R61	Resistor: fxd, ww, 13.32 ohms	28480	33B-26C	1			
R62	Resistor: variable, ww, 100 ohms mounted on insulating plate	28480	2100-0021	1			
R63	Resistor: fxd, composition, 27 ohms ±10%, 1 W	01121	0690-2701	1			
R64	Resistor: fxd, composition, 22,000 ohms ±10%, 2 W	01121	0693-2231	2			
R65	Same as R10						
R66	Same as R45						
R67	Resistor: fxd, composition, 18,000 ohms ±10%, 2 W	01121	0693-1831	1			
R68	Same as R64						
R69	Same as R10						

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℔ Stock No.	TQ*			
R70, 71	Resistor: fixed, deposited carbon, 680 ohms ± 1%, 2 W	01121	0727-0085	2			
R72	Not assigned						
R73	Resistor: fixed, composition, 5600 ohms ± 10%, 1 W	01121	0690-5621	1			
R74	Resistor: fixed, composition, 18,000 ohms ±10%, 1/2W	01121	0687-1831	1			
R75	Model 330B Same as R9						
	Model 330C/D Resistor: fixed, deposited carbon, 15,800 ohms ± 1%, 1 W	19701	0730-0036	1			
R76	Resistor: fixed, composition, 680 ohms ± 10%, 1 W	01121	0690-6811	1			
R77	Resistor: fixed, composition, 100,000 ohms ± 10%, 1/2 W Optimum value selected at factory Average value shown	01121	0687-1041	1			
R78	Resistor: fixed, composition, 18,000 ohms ± 10%, 1/2 W Optimum value selected at factory Average value shown	01121	0687-1831	1			
R79	Not assigned						
R80	Model 330B Not assigned						
	Model 330C/D Resistor: fixed, composition, 150,000 ohms ± 10%, 1 W	01121	0690-1541	1			
R81, 82, 83	Not assigned						
R84, 85	Same as R11						
R86	Same as R48						
R87	Resistor: fixed, composition, 68,000 ohms ± 10%, 1 W	01121	0690-6831	1			
R88	Not assigned						
R89	Resistor: variable, composition, 50,000 ohms ± 20%, 1/2 W	12697	2100-0013	1			
S1	Model 330B/C Not assigned						
	Model 330D Switch, rotary: used in Detector Assembly, 5 position	76854	3100-0016	1			

* See introduction to this section

Table 5-1. Replaceable Parts (Cont'd)

Ckt Ref.	Description	Mfr *	℗ Stock No.	TQ*			
S2	Input Switch Assembly	28480	33B-19B	1			
	Switch, rotary: INPUT, "AF-RF", less components	76854	3100-0021				
S3	Frequency Range Switch Assembly includes R26 thru R31	28480	33B-19W	1			
S4	Function Switch Assembly	28480	33B-19A	1			
	Switch, rotary: function, less components	76854	3100-0035				
S5	Switch, toggle: SPST	04009	3101-0001	1			
S6	Model 330B Voltmeter Switch Assembly: complete includes C25, R58	28480	33B-19F	1			
	Model 330C/D Voltmeter Switch Assembly: complete includes R58	28480	33B-19G	1			
	Switch, voltmeter range: less components	76854	3100-0019				
T1	Transformer, power	28480	9100-0289	1			
V1	Model 330B, not assigned						
	Model 330C/D Tube, electron: 6H6	80131	1930-0021	1			
V2, 3	Tube, electron: 6SJ7	80131	1923-0037	4			
V4	Tube, electron: 6J5	80131	1921-0008	2			
V5	Same as V2						
V6	Tube, electron: 6AC7	80131	1923-0014	3			
V7	Tube, electron: 5Y3GT	80131	1930-0010	1			
V8	Tube, electron: 6Y6G	80131	1923-0040	1			
V9	Same as V2						
V10	Tube, electron: 0D3	80131	1940-0009	1			
V11	Same as V4						
V12, 13	Same as V6						

* See introduction to this section

Table 5-1. Replaceable Parts (cont'd)

Ckt Ref.	Description	Mfr *	ⓗ Stock No.	TQ*		
	MISCELLANEOUS					
	Binding Post Assembly: black	28480	5060-0632	4		
	Binding Post Assembly: red	28480	5060-0633	4		
	Button, plug: 3/8" diameter	28480	6960-0001	1		
	Coupler, flexible	28480	5060-0629	1		
	Connector, coaxial, male	28480	1251-0014	1		
	Detector Assembly: complete	28480	33B-40	1		
	Drive, cable, assembly	28480	5060-0607	1		
	Escutcheon, dial window	28480	5040-0609	1		
	Holder, fuse	28480	1400-0084	2		
	Insulator, binding post: single	28480	0340-0089	1		
	Insulator, binding post: double	28480	0340-0086	7		
	Jewel, pilot light	28480	1450-0020	1		
	Knob: INPUT, BALANCE	28480	0370-0029	2		
	Knob: AF-RF, METER, RANGE RMS VOLTS	28480	0370-0035	4		
	Lampholder, for 2 pin base	28480	1450-0022	1		
	Knob: BALANCE (330D/DR only)	28480	0370-0057	1		
	Knob: FREQUENCY	28480	0370-0038	2		
	Window, dial	28480	202A-40B	1		
	Operating and Service Manual	28480	330B-902	1		

* See introduction to this section

MANUAL CHANGES

MODEL 330B/C/D

Manual Serial Prefixed: 351-

HP Part No. 330B/C/D-902

Model 330B/C

Instrument Serial Number	Make Manual Changes
351-10671	1

Model 330D

Instrument Serial Number	Make Manual Changes
351-10746	1

HP Part No. and HP Stock No. are synonymous

CHANGE #1 Figure 4-9. Model 330B/C/D Amplifier and Filter Section

Add a capacitor C39* in parallel with C13B

Table 5-1. Replaceable Parts

Add C39* (factory adjusted value) capacitor, fixed, titanium dioxide, 4.7 pf ±5%, 500 vdcw, hp Stock No. 0150-0042

MANUAL BACKDATING CHANGES

Model 330B/C/D

DISTORTION ANALYZER

Manual Serial Prefixed: 351-
Manual Printed: 10/64

To adapt this manual to instruments with other serial prefixes, make changes shown in tables.

NOTE

This backdating manual change sheet makes this manual applicable to the earlier instruments. Instrument-component values that differ from those in the manual, yet are not listed in the backdating sheet, should be replaced using the stock number given in the manual.

Instrument Serial Prefix	Make Manual Changes
351-	1
246-	1, 2
204-	1, 2

Instrument Serial Prefix	Make Manual Changes
009-	1, 2
Serial 5668 to 4954	1, 2, 3

Model 330B

Instrument Serial Number	Make Manual Changes
4953 to 3997	1 through 4
3996 to 3072	1 through 5
3071 to 2023	1 through 6
2022 to 1169	1 through 7
1168 to 803	1 through 8
802 to 672	1 through 9

Model 330C/D

Instrument Serial Number	Make Manual Changes
4953 to 2020	1 through 4
2019 to 1694	1 through 5
1693 to 1458	1 through 6
1457 to 1144	1 through 7
1143 to 1075	1 through 8
1074 to 672	1 through 9

CHANGE 1 Change Power Transformer T1 to HP Stock No. 9100-0011

CHANGE 2 Table 5-1. Replaceable Parts

R58, Resistor Set HP Stock No. 33B-26D, replaces the single resistor in previous instruments. When ordering replacement for R58, order the Resistor Set which consists of separately replaceable resistors R58A through R58G.

Supplement B for Model 330B/C/D-910

CHANGE 3 Table 5-1. Replaceable Parts

Delete C36
Change I1 to HP Stock No. 2140-0009, clear incondescent lamp, No. 47, 6-8 V.
Change R53 to HP Stock No. 0730-0085, 316 K ohms

Change the following parts under Miscellaneous:

Dial window escutcheon to HP Stock No. 5040-0231
Lamp holder to HP Stock No. 1450-0011

Add, Red indicator light, HP Stock No. 1450-0056
Delete, Pilot light jewel, HP Stock No. 1450-0020

CHANGE 4 The following changes are included to cover instruments which have not been modified according to Service Note 330B-6C for HP Model 330B/C/D Distortion Analyzers, Serial No. 4954 and below. To modify the instruments refer to Service Note 330B-6C on the following page.

Change Resistors R70 and R71 to HP Stock No. 0689-6215, 620 ohms
Change Resistor R73 and R74 to HP Stock No. 0689-6225, 6200 ohms
Delete CR1 and CR2 and replace with a dual diode electron tube V14, type 6H6, HP Stock No. 1930-0022. (See circuit diagram furnished with Service Note 330B-6C.)
Add Resistor R72 HP Stock No. 0813-0002, 7 ohms, 2 w in the heater circuit.

CHANGE 5 Figures 4-7 and 4-8. Model 330C/D and Model 330B Power Supply and Voltmeter Section. Refer to Figure 2.

Add Resistor R51 HP Stock No. 0690-5621 between the junction of R56 and R50 to ground
Add a capacitor C18B (20 μf) from junction of R51 and R56 to ground.
Change Resistors R49 and R50 to HP Stock No. 0690-5621. Refer to Figure 2.

Change Capacitor C17AD (40 μf) to C17AB (40 μf).
Change Capacitor C18AD (40 μf) to C17C (20 μf).
Change Capacitor C17C (20 μf) to C17D (20 μf).
Change Capacitor C18C (20 μf) to C18A (20 μf).
Change Capacitor C17B (20 μf) to C18D (20 μf).
Change Capacitor C18B (20 μf) to C18C (20 μf).
Change Capacitor C28BC (40 μf) to C28B (40 μf).

This change results in adding an RC filter section to the plate supply of V11.

Supplement B for Model
330B/C/D-910

SERVICE NOTE

⊕ MODEL 330B/C/D DISTORTION ANALYZERS
SERIAL NO. 4954 AND BELOW

METER CIRCUIT MODIFICATION

The meter circuit in the above instruments can be made less subject to line voltage variations and also more reliable by eliminating the 6H6 tube for V14.

If an instrument is operating properly, no changes need be made. When repair is required, modification of meter circuit is also recommended. See figure 1 for modification details.

V14 is replaced by two ⊕ Stock No. 1901-0027 silicon diodes. These diodes are a special high performance junction type.

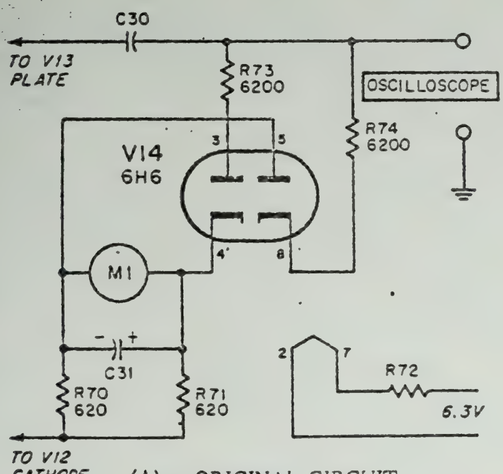
These diodes have a junction that is less than 0.0005 inch in diameter and, if dropped, a mechanical failure may occur at the junction. After installation the diodes will withstand any shock that the entire instrument can withstand.

The wires and series resistor (R72) supplying heater voltage to V14 pins 2 and 7 should be removed. The lugs on the socket for V14 can then be used as tie points for diode mounting. Be sure to observe polarity when connecting the diodes. Covering the top of V14 tube socket with a piece of tape will prevent insertion of another 6H6 tube at a later date.

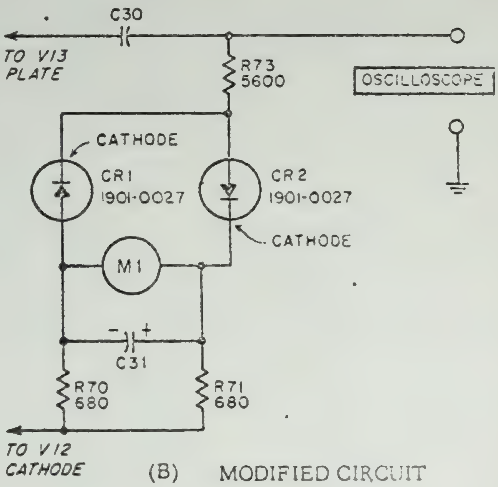
After completing the meter circuit modification, check voltmeter calibration, tracking, and frequency response.

The following parts will be required:

Quantity	Description	⊕ Stock No.
2	Silicon Diode for CR1, CR2	1901-0027
2	Precision Resistor, 680 ohms ±1%, 1/2 watt	0727-0085
1	Composition Resistor, 5600 ohms ±10%, 1 watt . . .	0690-5621



(A) ORIGINAL CIRCUIT



(B) MODIFIED CIRCUIT

Figure 1. Meter Circuit Modification

CHANGE 6 Figure 4-9. Model 330B/C/D Amplifier and Filter Section.

Change C14 to HP Stock No. 0150-0003, 51 pf
Change R6 to HP Stock No. 0690-4701, 47 ohms
Change color coding on power transformer primaries as follows:

Change Black-Yellow lead to White
Change Black-Green lead to Brown
Change Black-Red lead to Blue

CHANGE 7 Figures 4-7 and 4-8. Model 330B and Model 330C/D Power Supply and Voltmeter Section.

Delete Resistors R77 and R78
Change Resistor R57 to HP Stock No. 0730-0112, 2 M ohms

CHANGE 8 For the following changes use Schematic Figure 2.

330C, D: add R82 150 kΩ resistor in series with grid 4 of V13. Delete C35 and R81
330B, C, D: Change R75 to 560 Ω and connect as in figure 2

CHANGE 9 For the following changes use Schematic Figure 3.

330B, C, D: in the power supply, delete R84 through R87 and C37. Change V9 to type 6SQ7-GT; connect as in Figure 3
R62 is changes to 50Ω variable and R63 is changed to 51Ω; for more adjustment range, use current values.
330C, D: Delete R82

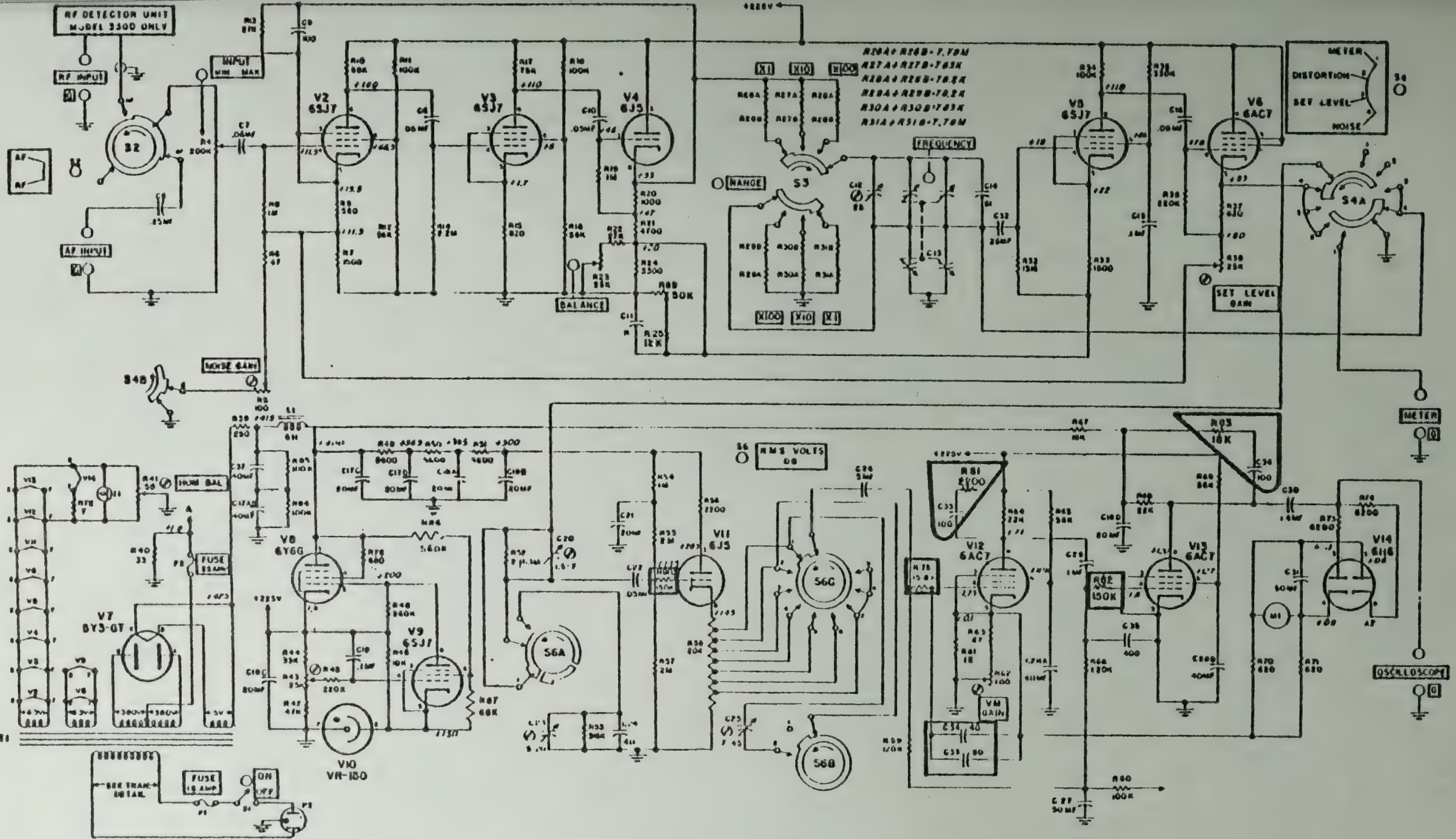


FIGURE 2

SCHEMATIC DIAGRAM OF MODEL. 330

Ic-5

Note: Parts enclosed by heavy lines found only in Models 330C and 330D

SERVICE SHEET NO. 1

This circuit is basically correct, but small differences may exist for any particular instrument. Comparison and cross-checking will enable identification of necessary parts

Hewlett-Packard Company
395 Page Mill Road
Palo Alto, Calif.

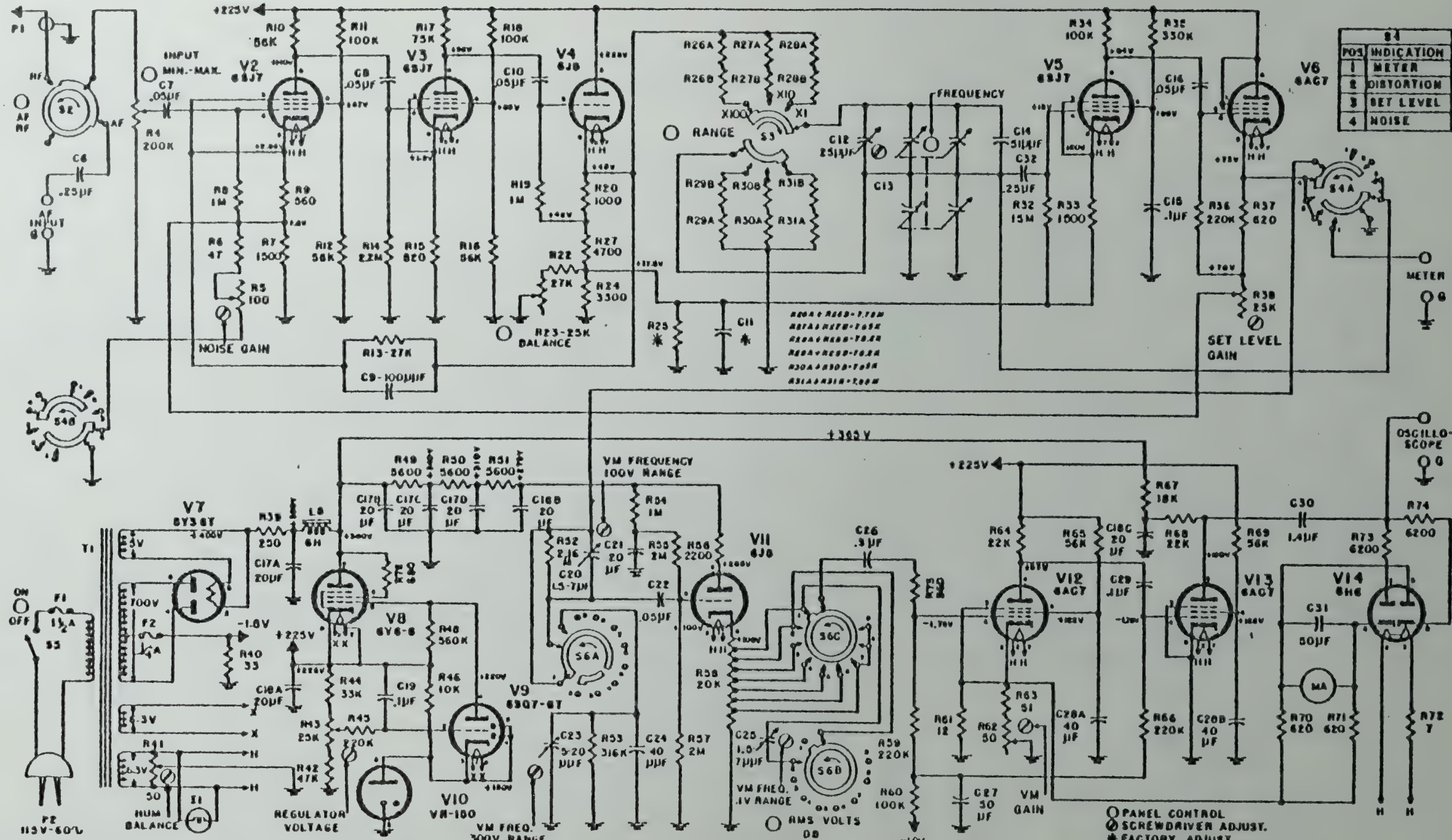


FIGURE 3

SCHEMATIC DIAGRAM OF -HP- MODEL 330 DISTORTION ANALYZER

SERIAL 672 TO

APPENDIX

CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11264	Dymec, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G. E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G. E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Mfg. Co.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.

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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Texas Instruments, Inc., Metals and Controls Div., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semi-conductor Div.	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics, Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

CODE NO.	MANUFACTURER	ADDRESS
0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000D	Connex Corp.	Oakland, Calif.
0000E	Fisher Switches, Inc.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000G	Microwave Engineering Co.	Palo Alto, Calif.
0000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000R	Metro Cap. Div., Metropolitan Telecommunications Corp.	Brooklyn, N.Y.
0000S	Moulton Electronics	San Carlos, Calif.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000V	Imperial Electronics, Inc.	Buena Park, Calif.

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Revised: 2 June 1961

From: F.S.C. Handbook Supplements
H4-1 Dated Oct. 1960
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Tucson 85706
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North Hollywood 91604
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Pensacola 32575
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Atlanta 30348
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TWX: 810-766-4890

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Tel: (617) 861-8960
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TWX: 810-242-2900

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Roseville 55113
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TWX: 910-764-0830

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Station E
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Albuquerque 87123
Tel: (505) 292-1330
TWX: 910-989-1185

156 Wyatt Drive
Las Cruces 88001
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6 Automation Lane
Computer Park
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Tel: (518) 458-1550
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Cable: AARIS Bogotá
Telex: 044-400

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Bulevar de los Heroes II-48
San Salvador
Tel: 252787

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Zona 9
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Telex: 4192 Teletro Gu

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Canal Zone
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